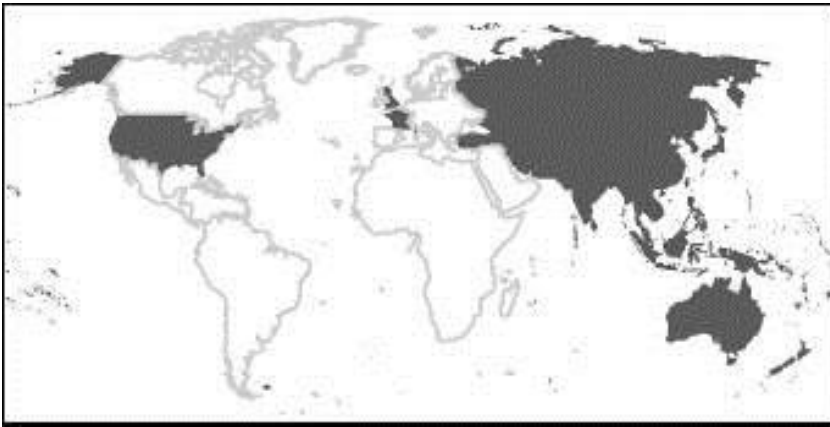


Monograph Series on Sustainable and Inclusive Transport

Assessment of Urban Transport Systems



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Monograph Series on Sustainable and Inclusive Transport

Assessment of Urban Transport Systems



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Assessment of Urban Transport Systems

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CONTENTS

	Page
Executive Summary	1
1. Introduction	3
1.1 Background	3
1.2 Objective	4
1.3 General approach.....	4
1.4 Context and expected use	5
1.5 Outline of the report.....	6
2. Conceptual Framework.....	7
2.1 Sustainable development	7
2.2 Transport and sustainable transport	7
2.3 Sustainable urban transport.....	10
2.4 A framework to assess sustainable urban transport.....	10
3. Development and Selection of Assessment Indicators	15
3.1 Identification and organization of candidate indicators.....	15
3.2 Application of criteria to select indicators for assessment	21
3.3 Final adjustment of indicator set	26
4. Description and Refinement of Selected Indicators	29
4.1 Indicator 1: Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modes	31
4.2 Indicator 2: Modal share of active and public transport in commuting	36
4.3 Indicator 3: Convenient access to public transport service.....	38
4.4 Indicator 4: Public transport quality and reliability	40
4.5 Indicator 5: Traffic fatalities per 100,000 inhabitants.....	45
4.6 Indicator 6: Affordability – travel costs as part of income	46
4.7 Indicator 7: Operational costs of the public transport system	47
4.8 Indicator 8: Investment in public transportation systems.....	49
4.9 Indicator 9: Air quality (PM10)	50
4.10 Indicator 10: Greenhouse gas emissions (CO ₂ eq tons/year).....	52
5. Sustainable Urban Transport Index.....	55
5.1 Normalization	55
5.2 Weighting	56

5.3 Calculation method.....	57
5.4 Practical calculation.....	58
5.5 Exemplification	59
6 Summary and Conclusions	65
6.1 Summary.....	65
6.2 Conclusions and further steps	66
References	67

LIST OF FIGURES

Figure 1	Copenhagen public transport share, 2014	37
Figure 2	Data process for city of Bangalore for SDG target 11.2 indicator	39
Figure 3	Example of a seven-point Likert scale for satisfaction survey	42
Figure 4	User satisfaction survey for BRTS in Indore city using 5-step scale	42
Figure 5	Customer satisfaction survey device	43
Figure 6	Example of wait assessment indicator of bus service	44
Figure 7.	An example of annual report of a transport company	48
Figure 8.	Air quality data for cities in Thailand	51
Figure 9.	Spider diagram showing performance of City X across SUTI indicators	61
Figure 10.	Illustration of performance of cities across indicators	64

LIST OF TABLES

Table 1.	Overview of some sustainability related impacts from transport	8
Table 2.	SDGs and targets of direct relevance for transport	9
Table 3.	Summary of framework elements	11
Table 4.	Meta-criteria applied to present framework	12
Table 5.	Overview of selected sustainable transport indicator and index	16
Table 6.	Overview of indicators in two larger studies	18
Table 7.	Proposed Indicators for SDG targets with relevance for urban transport	20
Table 8.	Consolidated list of candidate indicators	22
Table 9.	Evaluation of indicators according to framework elements.	23
Table 10.	Assessment of indicators according to methodology.	24
Table 11.	Combined ranking of indicators	25
Table 12.	Final set of indicators for assessment of urban transport	27
Table 13.	Indicative outline of scoring criteria	33
Table14.	Overview of sustainable urban transport index	57
Table 15.	Data entry for individual city	59
Table16	Normalized result for individual city	60
Table 17.	Data entries for eight cities	62
Table 18.	SUTI ranking for eight cities	63

BOXES

Box 1.	Key terminology	5
Box 2.	Hypothetical example to evaluate 'City X' urban transport plan	35

Executive Summary

This study report presents the process of development of the Sustainable Urban Transport Index (SUTI), a tool that can be used for assessment and evaluation of sustainable urban transport systems for cities in the Asia-Pacific region. The report explains and illustrates how such an index was developed and will be used in three steps.

Firstly, a conceptual framework was drafted based on existing literature and policies on sustainable development and transport, including the Sustainable Development Goals. The framework ensures that the index reflects topics that are important for measuring sustainable urban transport.

Secondly, indicators were identified, reviewed and selected for the index. This was based on a review of existing indicator reports and studies, the application of indicator selection criteria, and the review of a draft set of indicators the Expert Group Meeting on Planning and Development of Sustainable Urban Transportation Systems held in Kathmandu on 22-23 September 2016 which led to a consolidated concise list of ten indicators for the index. These indicators are described in detail with regards to relevance, definitions, measurement units, range of empirical values for normalization, and data sources.

The final step was to construct the index. This involved decisions on ways to normalize, weigh and calculate the elements of index. The index is calculated and illustrated using data for eight hypothetical cities partly molded over real cities.

The sustainable urban transport index with ten indicators describing key aspects of sustainable urban transport for Asian cities was developed for assessment of urban transport systems.

Finalized ten indicators of the sustainable urban transport index

Nos.	Indicators	Measurement units	Weights	Normalization	
				MIN	MAX
1	Extent to which transport plans cover public transport, intermodal facilities ++and infrastructure for active modes	0 - 16 scale	0.10	0	16
2	Modal share of active and public transport in commuting	Per cent of trips	0.10	10	90
3	Convenient access to public transport service	per cent of the population	0.10	20	100
4	Public transport quality and reliability	per cent satisfied with service	0.10	30	95
5	Traffic fatalities per 100,000 inhabitants	Number of fatalities	0.10	35	0
6	Affordability – travel costs as part of income	per cent of income	0.10	35	3.5
7	Operational costs of the public transport system	Cost recovery ratio	0.10	22	175
8	Investment in public transportation systems	per cent of total investment	0.10	0	50
9	Air quality (PM10)	µg/m ³	0.10	150	10
10	Greenhouse gas emissions from transport	Tons/capita/year	0.10	2.75	0
			1.00		

Issues that require further attention include not least the availability, collection and processing of data, and how the index is to be deployed and used in practice. It would need policy support from cities to apply the SUTI consistently in the Asia-Pacific region. The issues include consistency of data, collection and interpretation.

The Regional Meeting on Sustainable Urban Transport Index held in Jakarta agreed at the ten indicators and index and recommended for pilot application of SUTI in selected cities.

1. Introduction

1.1 Background

Sustainable transport is a major concern in connection with urban development worldwide, not least in the Asia-Pacific region (UN ESCAP 2016). The Asia-Pacific region has witnessed rapid population growth and urbanization. In 2016, 48.7 per cent of the region's 4.3 billion population lived in urban areas. Projecting forward, more than half of the region's population will be urban residents by 2018¹ with the total regional urban population expected to reach 3.2 billion by 2050². The fleet of motor vehicles is also growing steadily in the region's cities. This rapid growth and increased urbanization will continue to stress urban transport systems and infrastructure leading to congestion, accidents and more consumption of fossil fuels and correspondingly raise greenhouse gas (GHG) emissions. Quality of life issues like loss of productivity and health also suffer as a follow-on impact. Given the increasing demand for urban mobility due to rapid urbanization and rural-urban migration, Asian countries and cities need to initiate integrated policies and make investment in improved urban public transport systems and services.

The adoption of the 2030 Agenda for Sustainable Development with the 17 Sustainable Development Goals (SDG's) in 2015 has provided a new impetus to address global development challenges including for transport in urban areas. Other recent and emerging global and regional commitments such as the Habitat III summit and its outcome the New Urban Agenda that was adopted in 2016 further emphasize the urgent need to tackle urban transport challenges.

Also in October 2016, the United Nations Secretary Generals' High-Level Advisory Group on Sustainable Transportation submitted its report 'Mobilizing Sustainable Transport for Development' calling for the development of sustainable urban mobility plans that support intermodal and interconnected transport, and the establishing of comprehensive monitoring and evaluation methodologies for sustainable transport by national and local governments (UN-HLAG 2016).

Ensuring progress towards sustainable urban transport will require tools to measure, monitor and report on performance in various cities, countries and regions using tools such as indicators and indices. Measurement and evaluation of sustainable urban transport system, services and policies and their implementation can support assessment of transport contribution to sustainable development. A set of key urban transport indicators and an index - easily populated with data can be very useful tool for assessment of urban transport system. The indicators and index can reflect state of urban transport performance in a city.

Today there is no comprehensive system of indicators or indices in place to measure and report on sustainable urban transport across cities in the Asia-Pacific region.

¹ Asia-Pacific Sustainable Development Outlook, ESCAP, ADB and UNDP, 2017.

² Statistical Yearbook for Asia and the Pacific 2015, ESCAP.

1.2 Objective

The objective of the study is to develop an appropriate methodology and choose to selected indicators and develop an index to measure sustainable urban transport system and services and progress towards SDGs in Asian cities.

The indicators and index are intended to serve as a tool to help summarize, compare and track the performance of cities across the Asia-Pacific region with regard to the contribution of sustainable urban transport to the SDGs more specifically to Goal 11 and Target 11.2.

The index is to be based on a set of indicators that will reflect the various modes of transport system, social, economic and environmental dimensions of sustainable urban transport and refer to contributions of transport within the relevant dimension of and goals for sustainable development.

1.3 General approach

The focus for the study is to demonstrate how a workable assessment tool to measure urban transport system and services can be developed.

The index is not built from ready data or any existing comprehensive database for sustainable urban transport across Asia. It is rather derived from a conceptual framework and selected indicators based on a comprehensive review of relevant technical and policy literature. In the process, several partial-data sources and collections have been consulted.

The approach taken involves two overlapping components, indicator selection and index-building.

The *indicator selection* component is based on general procedures and criteria for defining indicators in general and sustainable transport indicators in particular. Key references for this step include Pei et al (2010); Joumard and Gudmundsson (2010); Castillo and Pitfield (2010); Ramani et al (2011); Van Rooijen and Nesterova (2013), and Burggraf et al. (2015), as well as reports on the Sustainable Development Goals and associated indicator efforts (e.g. Habitat 2016).

Main steps in this component include:

- Definition of overall conceptual framework (purpose and scope for indicators).
- Identification of potential indicators from literature and other sources.
- Selection of indicators using criteria and expert consultations.

The *index building* component is based on literature on how to design indices in general (e.g. Nardo et al. 2005) and for sustainable transport in particular. This report adopts the simplified index development procedure including five steps as defined by Zheng et al (2013):

- Identifying the problem or issues to be measured (conceptual framework from component 1).
- Selecting appropriate indicators and variables (inherited from component 1).
- Normalizing the data to render them dimensionless.

- Weighting the components, and
- Aggregating the weighted components into a single composite index score.

Key words in the terminology adopted in this publication are shown in Box 1.

Box1: Key terminology

Indicator: a variable selected to represent a key property of a system or a wider phenomenon of interest. Indicators may be used directly or as elements in other measurement tools.

Index: a special type of indicator that consists of two or more indicators that each measure distinct system characteristics in separate units that are normalized and *aggregated*.

Framework: A mental construct that serves to delimit and organize topics and associated sets of indicators or indices according to conceptual, operational and utilization aspects.

Metrics: The specific operational design of an indicator in regard to how the values are measured, parameterized, calculated, normalized, combined, etc. (e.g. as tons per capita, or per unit of GDP).

Topic: Phenomenon or system property that an indicator seeks to measure (for example 'transport demand', 'air pollution' or 'accessibility').

City or urban area: Built-up area with a high population density governed by one or more political/administrative bodies. Not defined more specifically in this report. May be considered subsequently.

1.4 Context and expected use

The geo-spatial context is cities in the Asia-Pacific region. By 2018 half of the population in the region will live in cities.³ This region is geographically vast and diverse containing numerous cities with considerable variations in size, general conditions, and transport situations. It may be relevant at some point to focus SUTI on some sub-regions or size of cities, or to stratify the approach.

The main expected users of the proposed assessment tool are cities in Asia-Pacific countries and the UNESCAP. Users could also include national governments, other international organizations as well as NGO's involved in sustainable development and urban transport policy assessment. Once the indicator set and index are developed additional efforts of different entities in cities and countries would be necessary to collect and analyze required urban transport data. The indicators and index are intended for general communication, assessment, and dialogue in support of sustainable urban transport policies across Asian cities. The indicators and index have been developed with a view to balance between measuring what is necessary to support sustainable urban transport with what data could likely be made operationally available by many different cities on a regular basis.

³ Statistical Yearbook for Asia and the Pacific 2015.

Key aims are:

- To limit the number of variables to the few most essential ones,
- To avoid variables that are overly demanding or sophisticated to collect data, and
- To adopt an index calculation method that is as simple, transparent, and unbiased as possible.

1.5 Outline of the report

The report provides a summary of the conceptual basis and the process of selecting sustainable transport indicators and developing the index. It then describes the proposed indicators in detail. Finally, it presents the design of the Sustainable Urban Transport Indicator (SUTI) for assessment of urban transport systems and services with examples. Following this introduction, the report has the following structure,

- Chapter 2 summarizes the conceptual framework.
- Chapter 3 summarizes the process to develop and select indicators.
- Chapter 4 describes each of the ten indicators.
- Chapter 5 describes and exemplifies the SUTI.
- Chapter 6 provides summary and proposes next steps.

2. Conceptual Framework

The aim for the SUTI is to measure and support urban transport in the context of sustainable development. The fundamental concepts to understand and incorporate in the framework are therefore sustainable development, sustainable transport, and how they connect in the urban context.

2.1 Sustainable development

Sustainable development is the desired overall trajectory of development for people, the economy, and the planet. Transport is therefore to operate within boundaries defined by sustainable development. Key elements to be observed when measuring for Sustainable Development are,

- the basic WCED (1987) definition of Sustainable Development - '*Meeting the needs of the present without compromising the ability of future generations to meet their own needs*',
- the *three dimensions* or pillars of sustainable development, the social, environmental and economic one, also known as the 'triple bottom line', or as People, Planet, Prosperity in the 2030 Development Agenda,
- the *Sustainable Development Goals* (SDG's) that were also adopted in the 2030 Development Agenda, and the associated targets, measurement, and reporting frameworks.

It is therefore important to link urban transport to general sustainability concepts as well as to the Sustainable Development Goals.

2.2 Transport and sustainable transport

Transport systems

Transport systems form an integral part of society, the economy, and of the human impact on the planetary system. Therefore, transport is also important for sustainable development.

The generic components of all transport systems are *infrastructure*, *vehicles*, and *propulsive energy*, which are operated by humans, supported by computer systems and organizations. These jointly deliver *transport services*, which include the movement of people and goods.

Separate transport systems exist for land (road, rail), air, and sea transport. These are connected via terminals and intermodal exchanges. Subsystems (such as urban and intercity rail) exist for different transport markets.

Sustainable transport definitions

The terms 'sustainable transport' and 'sustainable mobility' have been coined to reflect the concerns over potential impacts of all transport systems and mobility on sustainable development, including economic, social and environmental impacts. Impacts can be positive (for example providing increased access to jobs) or negative (for example greenhouse gas emissions).

Despite the wide use of the term 'sustainable transport' there is no clear agreement on a global definition of 'sustainable transport' or what it means in detail. This is because the contributions of transport to sustainable development are diverse, complex, dynamic, and context-dependent.

The most widely-cited definition of sustainable transport was developed by the Canadian Centre for Sustainable Transportation in 1997 and has since been adapted by a number of other governing bodies around the world. The original definition refers to a sustainable transport system, which,

- “Allows the basic access needs of individuals and society to be met safely and in a manner consistent with human and ecosystem health, and within equity within and between generations.
- Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy.
- Limits emissions and waste within the planet’s ability to absorb them, minimizes consumption of non-renewable resources, reuses and recycles its components, and minimizes the use of land and the production of noise.” (Gilbert et al. 2002)

The definition contains many elements, illustrating how challenging it could be to measure if a certain transport system is fully sustainable or not.

Sustainable transport impacts

Transport impacts are the key elements in sustainable transport assessment. Comprehensive reviews of types of sustainable transport impacts can be found in literature such as Gudmundsson et al. (2016), Black (2010), Ieda (2010), and Rand Europe (2004). A summary of key impacts associated with sustainable transport is shown in Table 1 (Gudmundsson et al 2016).

Table 1. Overview of some sustainability related impacts from transport

Environmental	Social	Economic
Air pollution Consumption of land/urban sprawl Depletion of the ozone layer Disruption of ecosystems and habitats Global climate change Hydrologic impacts Introduction of exotic species Light pollution Noise pollution Release of toxic/hazardous substances Solid wastes Vibration pollution Visual intrusion and aesthetics Water pollution	Accidents Declining community livability/ community partitioning Human (psychological and physiological) health impacts Inequalities associated with negative environmental and health impacts Mobility barriers/inequalities for the disadvantaged Time wastage Visual pollution	Costs of transportation to customers/consumers Costs relating to accidents Depletion of non-renewable resources and energy supplies (<i>also an environmental and intergenerational equity concern</i>) Traffic congestion Transportation facility costs Transportation-related health costs

Sustainable mobility paradigm

The terms sustainable transport and mobility also allude to *paradigms and strategies* that have been developed to help make transport more sustainable,

The so-called *sustainable mobility paradigm* has the focus on mobility and accessibility (Banister 2008; Zegras 2006) as opposed to conventional focus only on motor vehicle speed and flows.

Monitoring for the sustainable mobility paradigm should focus on the efficiency of the transport system in delivering access and mobility for humans with quality, diversity and minimal impact, instead of high quantity and speed.

The sustainable mobility paradigm promotes a broad range of strategies (UN-HLAG 2016, Banister 2008),

- to avoid unnecessary transport ('Avoid' strategy)
- to shift transport from individual motorized transport to active modes and public transport ('Shift' strategy) and,
- to promote clean fuels and vehicles ('Improve' strategy)

SDG's and transport

There is not one dedicated Sustainable Development Goal for transport defined in the 2030 Development Agenda. Transport will nevertheless be important for achieving many of the SDG's, and several of the 169 specific SDG targets do address transport directly.

Table 2 below highlights the SDG goals and targets that are most directly relevant for transport.

Table 2. SDGs and targets of direct relevance for transport

Goal	Targets
3. Ensure healthy lives and promote well-being for all at all ages (<i>Road Safety</i>)	3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents
7. Ensure access to affordable, reliable, sustainable and modern energy for all (<i>Energy efficiency</i>)	7.2 By 2030, increase substantially the share of renewable energy in the global energy mix
	7.3 By 2030, double the global rate of improvement in energy efficiency
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation (<i>Sustainable infrastructure</i>)	9.1 Develop quality, reliable, sustainable and resilient infrastructure , including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all
11. Make cities and human settlements inclusive, safe, resilient and sustainable (<i>Sustainable (urban) transport for all</i>)	11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons
	11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management
12. Ensure sustainable consumption and production patterns (<i>Fuel subsidies</i>)	12.c. Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances
13. Take urgent action to combat climate change and its impacts	13.2 Integrate climate change measures into national policies, strategies and planning

However, not all the targets are equally relevant for sustainable transport planning at the urban level.

2.3 Sustainable urban transport

Urban transport is a particular transport market that is separate from, but interlinked with long-distance transport connections. Urban transport consists almost completely of land transport systems (road and rail) although in some cities also water and to a lesser extent air (helicopters, drones, etc.).

The demand for urban passenger transport mainly arises from the need to travel to work, and access education, retail shopping, health service, and social interaction. These services are provided by private, public and semi-public forms of motorized and non-motorized transport. The demand for urban goods transport arises from the consumption of products and services by urban dwellers and businesses, the distribution of products manufactured in the city, and the need to remove waste.

Urban transport systems are different from city to city but share some general features, such as,

- a high spatial intensity of interaction,
- a mix of various transport modes and subsystems,
- positive and negative impacts concentrated on limited areas.

As mentioned not all the transport relevant SDG targets in Table 2 are directly intended for the *urban* transport policy level. Target 7.2 on renewable energy, Target 7.3 on energy efficiency, Target 12c on fossil-fuel subsidies, and Target 13.2 on climate change measures are for example primarily addressing planning and action at national level.

However, the topics covered by these targets (energy efficiency, fossil/renewable fuel use and related transport GHG-emissions) are nevertheless still important to address also at the urban level. A kind of proxy target should be defined for those impacts.

2.4 A framework to assess sustainable urban transport

At this point no common global framework to assess and report progress on SDG targets at the local or city level has been officially proposed. Therefore, a dedicated framework has been devised.

Based on the previous sections the key aspects to include in a framework for assessment of sustainable urban transport system can be summarized as follows:

- *The positive and negative impacts* of urban transport systems on the Sustainable Development dimensions (especially main impacts for urban transport such as accessibility, traffic safety, air pollution, greenhouse gasses). Such impacts need to be tracked.
- *The sustainable mobility paradigm*, which supports cities in planning for sustainable transport, by combining ‘avoid-shift-improve’-type strategies: Avoiding unnecessary transport, encouraging active and public modes, and improving vehicles, fuels and traffic management. Monitoring for such strategies should be supported.
- *The Sustainable Development Goals* and targets that relate specifically to urban transport. These include Targets 3.6, 9.1, 11.2, 11.6, plus what we call a ‘proxy’ target for urban transport

energy use/climate change impact, which does not have an obvious urban level SGD target. Progress towards these targets need to be monitored.

The framework is summarized in Table 3. The meaning of the framework is that each aspect and dimension should be represented by at least one indicator. The framework is therefore used to guide the identification and selection of topics and indicators for the SUTI.

Table 3. Summary of framework elements

Aspects	Dimensions
Sustainable development	Economic dimension impacts
	Social dimension impacts
	Environment dimension impacts
Sustainable mobility -paradigm	Avoid strategy
	Shift strategy
	Improve strategy
SDG targets relevant for urban transport	3.6 Deaths and injuries from road traffic
	9.1 Quality, reliable, sustainable, resilient infrastructure
	11.2 Access to safe, affordable, accessible and sustainable transport systems for all,
	11.7 Universal access to safe, inclusive and accessible, green and public spaces
	11.6 Adverse environmental impact including air quality
	7.3 Improvement of energy efficiency 13.2 Integrate climate change measures

Check of the framework

To verify the adequacy of the framework it was checked against a sustainable transport ‘meta-framework’ that was developed for this purpose by Cornet and Gudmundsson (2016) (Table 4).

Table 4. Meta-criteria applied to present framework

	Aspect	How addressed in the framework?
Conceptualization		
1	Adopting an explicit, comprehensive, and holistic view on sustainability	Adopting view based on WCED, triple bottom line, and SDGs
2	Allowing a long-time horizon	By including GHG/climate change and resource concerns in the framework
3	Integrating land use and transportation on a broad geographic scale	Geographical scale is the city and surroundings. Land use and urban planning are addressed
4	Capturing interactions to identify trade-offs	Interactions are not explicitly dealt with in framework. Interactions (e.g. between better mobility and higher emissions) can be identified by monitoring trends using the indicators individually. Trade-offs are for example embodied in aggregation mechanisms in the index. Alternative designs can be considered as mentioned in summary
5	Supporting consistency between transport and sustainability objectives	Adopting SDGs and sustainable mobility paradigm. Transport should provide access to fulfill needs while considering environmental limits as measured in the index
6	Ranking of sustainability impacts	Sustainability are ranked equal across the three domains in the index by way of weighting
7	Informing strategic sustainable transport choices	Goals for sustainable urban mobility are included. Index could help inform strategic choices, e.g. learning from best performing peers or reprioritize efforts
Operationalization		
1	Creating an indicator system logic based on an understanding of linkages	Framework logic will recognize that transport systems require input to produce services while also producing impacts. Linkages are not modeled
2	Supporting well founded target setting	City or other organizations may decide on targets independently or with support from index. Not a purpose of this framework
3	Supporting integrated assessment	Integrated assessment is the essence of an integrated index
4	Ensuring cost- effectiveness of monitoring	Cost-effectiveness considered but not analyzed in this pilot project
5	Making the framing process explicit and transparent	Framing process is described in report
6	Applying indicator selection quality criteria	Indicator criteria are applied in selection and design of index
Utilization		
1	Connecting to goals and strategies	Index is connected to SDGs and Avoid-Shift-Improve strategies
2	Integrating vertically in the organization governance	Organizational issues not considered. Using Index could provide basis for integrating between strategic and operational levels of city administration.
3	Integrating horizontally between governance entities	Governance not considered. Using SUTI index in management could build connections between connect divisions/districts
4	Engaging with stakeholders and context	Stakeholders could be invited to select indicators, define scales or weights or use of index
5	Communicating externally	The purpose of the index is to serve as communication device
6	Aligning with agency capabilities and constraints	Final design of index must be aligned with e.g., data providing capabilities of cities
7	Leadership for adapting to and enabling change	Beyond scope
8	Providing periodic feedback	Main point of use of SUTI index is to provide periodic feedback

Adapted from Cornet and Gudmundsson, 2016.

The meta-framework allows assessing if practical indicator frameworks such as the SUTI using criteria based in what research literature has identified as key requirements for a comprehensive sustainable transport assessment framework. It applies criteria at the conceptual, operational, and utilization levels of indicators systems.

As seen from Table 4 the SUTI framework fulfills most criteria to a high or at least some degree. Some of the criteria can only be applied when SUTI is deployed in practice.

3. Development and Selection of Assessment Indicators

This chapter provides a summary of the development and selection process. Based on the conceptual framework, the work to identify and select indicators has involved three steps:

- identification and organization of candidate indicators from the literature,
- application of criteria to propose a consolidated indicator set,
- final adjustment of indicator set based on an expert workshop and a regional meeting.

3.1 Identification and organization of candidate indicators

The focus in the first step has been to identify topical indicators already existing or proposed in relevant literature or reports. This allows SUTI to be built primarily on existing work and recognized indicators, rather than developing entirely new, non-established indicators. However, in a few cases new indicators for important topics were developed as part of the process and final adjustment.

General literature review

Many studies and reports presenting sustainable urban transport indicators and/or indices were collected and reviewed, based on literature and internet search. An overview of the studies that offered the most valuable input to develop SUTI indicators is given in Table 5. Most of these reports were 'pure' sustainable transport studies, while some other were general urban indicator studies where sustainable transport formed a separate section within a wider indicator set.

The focus in the identification process was on publications reflecting a somewhat similar understanding of sustainable urban transport as in the framework proposed in chapter 2. Also included were reports with indicators that have been operationalized and applied to measure sustainable transport in several cities, mostly including cities in the Asia-Pacific region. In total around 25 indicator publications were reviewed initially.

Each study was classified in categories as shown in Table 5, and the indicator definitions provided in each reference were extracted to a spreadsheet database containing in total 429 indicator titles (with numerous overlapping ones – see about consolidation of the set further below).

Table 5. Overview of selected sustainable transport indicator and index

REFERENCES	TYPE	SCALE	SCOPE	APPLICATION	# INDI-CATORS	APPLIED
Sustainable Transport indicator/index						
WBCSD 2016	Indicators	Urban	Internal	Worldwide	19	6 cities
A.D. Little 2014	Index	Urban	Comparative	World	19	84 cities
KOTI 2015	Index	Urban	Comparative	Korea	24	Multiple cities
Siemens 2008	Index	Urban	Comparative	World	15	Multiple cities
Marzieh 2015	Index	Urban	Academic	Melbourne	9	1 city
Reddy et al 2013	Index	Urban	Comparative	India/World	7	5 cities
Bachok 2015	indicators	Urban	Internal	Malaysia	17	Not yet
ECOMOBILITY 2013	Indicators	Urban	Internal	Europe	20	Several cities
Ahangari 2015	index	National	Comparative	OECD	11	Several count
CIVITAS (May) 2016	Indicators	Urban	Internal	Europe	28	Partly
Zheng et al. 2013	Index	State	Comparative	US	24	Several states
Zito 2011	Index	Urban	Comparative	Europe	12	Multiple
Georgouli 2015	Index	Urban	Academic	Copenhagen	11	1 city
SLoCaT 2014	Indicators	General	(Open)	World	14	No
Litman 2016	Indicators	General	Academic	World/Us	20	No
Bongardt et al 2011	Indicators	General	(Open)	World	10	No
Steenberghen 2013	Indicators	Urban	Comparative	Europe	6	No
Olofsson 2016	Indicators	Urban	Internal	Sweden	21	1 city
Castillo 2010	Index	Urban	Academic	UK	15	Partly
Gilbert et al 2002	indicators	National	Internal	Canada	14	1 country
General set or index with transport as a domain/section (#indicators refer to transport only)						
SDG-IAEG 2016	Indicators	Global	Multiple	World	6	Not yet
HABITAT 2016	Indicators	Urban	Multiple	World	3	Not yet
GCIF 2015	Indicators	Urban	Multiple?	World	9	Several cities
Global City Rep 2015	Index	Urban	Comparative	World	3	60 cities

Note: Red: Only Asia. Orange: Partly Asia

This review provided a general overview over which types of indicators are typically proposed, how they are processed and selected, how indices are defined, and sometimes how results are presented and (more rarely) how the information is utilized.

Broadly speaking, the agreement over what to include and measure is very high at the level of general domains (most address the three sustainability dimensions somehow), moderate to high with regard to sub-domains and topics such as transport modes, traffic safety, and pollution, limited with regard to actual indicators, and quite low with regard to the specific metric design of those indicators that are proposed by several studies.

Key studies

Three of the studies were found to be particularly useful, with comprehensive indicator sets, relatively detailed definitions and explanations of metrics, and (to some extent) indicators with actual data:

The Sustainable Mobility 2.0 Project is conducted by the World Business Council for Sustainable Development (WBCSD 2016). The project has developed a set of 19 urban transport indicators for use by cities worldwide. It has so far been applied in six cities, three of which are in Asia. The study does not produce a comparative index. The indicators are shown in brief in Table 6. The indicators cover many aspects of sustainable urban mobility with an emphasis on less privileged groups. For each indicator, a detailed methodology is offered that allows a city to operationalize the indicators and

compare themselves with other cities or themselves over time. This process has been completed with assistance from the WBCSD team by so far six cities, three of which are in Asia. One of the elements of the methodology, namely the scaling used for normalizing several of the indicators is partly used in the present report. Excellent detailed reports are available for case studies in two of the cities that applied the method, including Indore, India (WBCSD 2016b).

However, the WBCSD Sustainable Mobility project also makes clear some of the challenges for a SUTI index. Many of the most interesting indicators in their set cannot be used unless cities undertake efforts to collect and produce new data following the WBCSD Sustainable Mobility guidance or other procedures. This includes for example travel surveys to collect information on travel distance and other surveys, as well as the use of transport models or other tools to produce data on traffic volumes, energy consumption and emissions, which are all highly relevant indicators for which general databases do not exist. Such efforts are demanding and not systematically pursued by cities, especially not developing cities.

The Arthur D Little report “The Future of Urban Mobility” made for the International Union for Public Transport (UITP) (Arthur D Little 2014). The study also includes 19 urban transport indicators. 84 cities are covered, 30 of which in Asia-Pacific region. The study is an update of a 2011 report and an earlier study (Siemens 2008) using (older) UITP data. In addition to traditional transport indicators the AD Little report also introduces a range of more ‘novel’ ones like car sharing performance, smart card penetration, and increase of share of zero-emission modes. The participating cities are mostly Megacities, members of the C40 network, and other larger cities with resources. Like the in WBCSD report case studies illustrate the range of data reported for each indicator for a selection of cities. The report reveals little about the sources of data for the indicators for each city but it seems to be a similar process to the WBCSD where the project has worked jointly with the selected cities to produce or extract the needed data.

The ‘Sustainable Urban Transport Evaluation’ (SUTE) system is the third particularly relevant study. It has been developed by the Korean Transport Institute and the framework is applied to all major cities in the Republic of Korea by the government, using 24 indicators (KOTI 2015). 12 of the indicators are quantitative so-called ‘status’ indicators while 12 others represent more qualitative aspects or urban transport planning. Each of the participating cities are reviewed by an expert panel for items such as ‘Policy efforts for traffic safety’ and ‘Policy efforts for improving public transport’. The policy review has a weight of 40 per cent in the combined assessment conducted for each city, where performance on quantitative status indicators like CO₂ emissions is given 60 per cent.

Table 6 indicates only limited overlap of indicators between these two references.

Table 6. Overview of indicators in two larger studies

WBCSD (2016)	Arthur D Little (2014)
Affordability of public transport	Financial attractiveness of public transport
Accessibility for mobility impaired groups	Share of public transport in modal split
Air pollution	Share of zero-emission modes in modal split
Noise	Roads density
Fatalities	Cycle path network density
Access to mobility services	Urban agglomeration density
Quality of public area	Smart card penetration
Urban functional diversity	Bike sharing performance
Commuting travel time	Car sharing performance
Economic opportunity	Public transport frequency
Net public finance	Initiatives of public sector
Mobility space usage	Transport related CO ₂ emissions
Emissions of greenhouse gases	NO ₂ concentration
Congestion and delays	PM ₁₀ concentration
Energy efficiency	Traffic related fatalities
Opportunity for active mobility	Increase of share public transport in modal split
Intermodal integration	Increase of share of zero-emission modes
Comfort and pleasure	Mean travel time to work
Security	Density of vehicles registered

Note: Color indicates full or partial overlap

SDG and UN HABITAT indicators

In addition to these key transport specific indicator sets, it is important to reflect ongoing work on indicators for the SDG's in general and at the urban level.

Under the United Nations Statistical Commission, the 'Inter-Agency Expert Group on Sustainable Development Goal Indicators' (IAEG-SDG 2016a) has developed a global set of indicators that are supposed to be used for tracking progress towards all of the 2030 SDG targets at the national and global levels.

Currently 229 indicators are included in the framework. Specific indicator sets to be applied at the sub-national level (including cities) are not yet proposed. However, it is expected that the global indicators will form a core reference also for indicators reported at the local level (UN ECOSOC 2016).

The IAEG-SDG has conducted a comprehensive assessment of the status of feasibility for each indicator. Each indicator is placed in one of three 'tiers':

Tier 1: Indicator conceptually clear, established methodology and standards available and data regularly produced by countries.

Tier 2: Indicator conceptually clear, established methodology and standards available but data are not regularly produced by countries.

Tier 3: Indicator for which there are no established methodology and standards or methodology/standards are being developed/tested.

Ideally only indicators on Tier 1 and Tier 2 should be considered for the SUTI.

The UNHABITAT has made important contributions to the SDG indicator work by addressing in particular indicator to measure SDG goal 11 “Sustainable Cities and Communities”. This goal includes Target 11.2 that is the only SDG target that deals explicitly with urban transport (Habitat 2016). The report contains a proposed indicator for this target but no actual applications or data.

As it was seen earlier in Table 2 there are other SDG targets related to (urban) transport than target 11.2. Various other bodies have proposed indicators as part of the IAEG-SDG framework.

Table 7 shows the ‘transport related’ indicators of this set, meaning all the indicators that have been defined in the IAEG-SDG process, and which relate to the transport targets as were identified previously in chapter 2. For each target the indicator is listed, as well as the Tier levels adopted by IAEG-SDG (IAEG-SDG 2016b). In addition, the relevance of the target/indicator for urban transport is reflected.

Comprehensive data initiatives

In addition to the relevant studies already described there are a few other initiatives that deserve mention as potential contributors to SUTI indicators and data.

One is the *Global City Indicators Facility* of the World Council of City Data (GCIF 2015) which has formed the first standard in the area of urban indicators, the ISO 37120. This initiative includes nine transport indicators within a framework covering a wide range of other domains. 257 cities are currently partners in the GCIF (<http://www.cityindicators.org/Participants.aspx>). How many of these have actually collected and reported data (standardized or not) is not clear, although examples of several cities that have applied and reported ISO 37120 indicators can be found.

Another activity is the *City Prosperity Initiative (CPI)* of the UN Habitat. According to UN Habitat (2016) the CPI has been proven in more than 400 cities across the world and as a monitoring framework. Habitat sees it as having the potential to become the global architecture platform for the monitoring of SDG Goal 11.

Finally, one should mention the Mobility in Cities database by the UITP. As noted this database informs the AD Little study cited above, but it includes more data than applied there. There are presently 85 standardized indicators mostly relating to public transport performance. The data are for one year, 2012. The database has actual data for at least 63 cities, of which 14 are in Asia, mostly very large cities. A wider regional and global coverage is however vigorously pursued by the UITP. Previous versions of the same database covering the years 1995 and 2001 respectively were even wider ranging with up to 230 indicators including also items like energy consumption and traffic fatalities. Apparently the UITP has narrowed the scope for the most recent version.

Table 7. Proposed Indicators for SDG targets with relevance for urban transport

Goal	Target	Proposed indicator	Comment
3. Ensure healthy lives and promote well-being for all at all ages (<i>Road Safety</i>)	3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents	3.6.1 Death rate due to road traffic injuries	Tier I (WHO; UN-Habitat) <i>Injuries less well covered than fatalities</i>
7. Ensure access to affordable, reliable, sustainable and modern energy for all (<i>Energy efficiency</i>)	7.3 By 2030, double the global rate of improvement in energy efficiency	7.3.1 Energy intensity measured in terms of primary energy and GDP	Tier I (IEA/OECD) <i>Not intended/assessed for local/sector reporting</i>
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation (<i>Sustainable infrastructure</i>)	9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	9.1.2 Passenger and freight volumes, by mode of transport	Tier I (ICAO/UPU/UNEP) <i>Not intended/assessed for local/sector reporting</i> <i>Ambiguous in regard to sustainable transport</i>
11. Make cities and human settlements inclusive, safe, resilient and sustainable (<i>Sustainable (urban) transport for all</i>)	11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities	Tier II (UNHABITAT/UNEP) <i>Key indicator for sustainable urban transport. Does not fully capture all dimensions of the target ('safe, affordable, accessible and sustainable for all') and attention to vulnerable groups will require further disaggregation</i>
	11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	11.6.2 Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)	Tier I (WHO) <i>Not measuring transport contribution specifically</i>
12. Ensure sustainable consumption and production patterns (<i>Fuel subsidies</i>)	12.c. Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances,	12.c.1 Amount of fossil-fuel subsidies per unit of GDP (production and consumption) and as a proportion of total national expenditure on fossil fuels	Tier III (UNEP) <i>Not intended/assessed for local/sector reporting</i>

Additional references

Some studies advocate or develop qualitative indicators and rankings for urban transport reporting, in addition to quantitative ones.

For Olofsson et al (2015) this approach allows the subjective perceptions of citizens in regard to factors such as public transport service, sense of security, and quality of the urban environment to be brought into the assessment. These perceptions can sometimes be more informative about e.g. on the success

of planning efforts than some objective indicators. Olofsson et al applied one objective and one subjective indicator to each measured topic in a study they made together with a Swedish city.

Some other frameworks like WBCSD (2016) and KOTI (2015) referred to above also include several indicators based on local surveys, for example on citizen's perception of economic opportunity offered by the local transport system, or expert panel evaluation.

The Eco-Mobility Shift Framework (Kodukula 2013) also provides a qualitative review format. This framework has focus on reviewing a city's efforts to deliver according to the sustainable mobility paradigm; for example, regarding mobility management, public participation in planning, and finance for green mobility modes.

The use of qualitative indicators of these types may be highly informative and useful for a city but will obviously require that specific methodology and data collection procedures are defined.

3.2 Application of criteria to select indicators for assessment

The direct result of the process of indicator extraction from literature was a long unedited list of in total 426 topics and indicators with many duplicates and overlaps across the studies.

The next step was to compile and organize this extensive list of topics and indicators to eliminate similar and overlapping candidate indicators from the set. Many could be easily renamed and consolidated as they were essentially measuring the same variables, while others could be eliminated because they were either poorly defined, reflected less essential issues, or would likely require extensive data or analytical work to be applied. The number of indicators was thereby significantly reduced to reach a small indicator set of a manageable size for cities including only the more relevant indicators – a concise list.

The short listing applied two organizing principles:

The first principle was to temporarily apply a simple four field framework with four domains where all indicators could be tentatively allocated, namely 'Transport system', 'Social', 'Economic', and 'Environment'

These domains reflect key aspects of the SUTI framework and are widely applied in literature on sustainable transport indicators (see e.g. De Gruyter et al. 2017; Gillis et al 2016; Martino et al 2010; Jeon and Amekudzi 2005). While the three latter domains refer directly to the sustainable development dimensions (reflecting impacts of transport), the 'transport system' domain is important in support of decision making regarding transport planning and sustainable urban mobility strategies. The rule was to ensure that several 'candidate' indicators were retained for all four domains. The second principle was to exclude indicators which assumed problematic definitions or methodologies and which were not mentioned in at least two reports, as well as indicators that had not been found to be applied in practice with actual data in at least one city (preferably in Asia).

This resulted in a reduced indicator set, a consolidated list of 22 candidate indicators is shown in Table 8.

Table 8. Consolidated list of candidate indicators

Domain	Indicator	No. of references
Transport system	Land occupied by transport infrastructure	11
	Cars and two-wheelers per capita	3
	Walking and cycling networks	9
	Public Transport reliability	4
	Share of active and public transport modes in modal split	17
Social impacts	Access to public transport service	9
	Access to transport system for vulnerable groups	3
	Access to urban functions	4
	Travel time to work	8
	Satisfaction with mobility services	8
	Traffic fatalities and serious injuries	19
	Security (crimes in transport)	3
Economic impacts	Affordability of transport	8
	Congestion and other social costs	8
	Transport system costs to society	5
	Economic opportunity	2
	Transport fuel consumption	8
Environmental impacts	Greenhouse gas emissions from transport	14
	Air quality	19
	Low emission vehicles	2
	Noise levels	4
	Urban environmental quality	2

A set of 22 indicators within a multi-dimensional framework was not the end, only the starting point for the final selection. This shortlist set was still considered too complex and demanding for most cities to deliver and manage on a regular basis.

After grouping the indicators into the four domains the next step was to apply indicator selection criteria with the aim to reach two indicators per domain (8 indicators in total) to form the first draft indicator set for the SUTI.

As proposed by Castillo and Pitfield (2010) two sets of criteria were applied in this process:

- a) Criteria aiming to maximize the relevance of indicators to the concept of sustainable transport. This was done by scoring indicators from 1-3 for each dimension of the SUTI framework.
- b) Criteria aiming to maximize the methodological quality of the indicators. The six criteria were:
 - definition and concept available in existing reports,
 - has been applied in practice in several cities,
 - data regularly available or readily produced,

- clear interpretation possible,
- scale to normalize indicator for index can easily be defined,
- relevant and actionable for cities.

Also, here a score of 1-3 was used.

Both sets of criteria scores were applied subjectively by the consultant with a view to avoid bias.

For the first assessment, the shortlist of indicators was assessed against the elements in the framework developed in chapter 2, Table 3.

Each indicator was given 1 (low) to 3 (high) points or no points (blank) regarding each dimension in the framework. The scores were summed for each indicator. The result is shown in Table 9.

Table 9. Evaluation of indicators according to framework elements

INDICATORS		PEOPLE, PLANET, PROSPERITY			SUS MOBILITY PARADIGM			SDG TARGETS													
		ECONOMIC	SOCIAL	ENVIRONMENT	AVOID	SHIFT	IMPROVE	3.6 halve deaths and injuries from road traffic	9.1 provide quality, reliable, sustainable, resilient infrastructure	11.2 Access to safe, affordable, accessible and sustainable transport systems for all.	11.7 Universal access to safe, inclusive and accessible, green and public spaces	11.6 reduce adverse environmental impact including air quality	JOINT ASSESSMENT								
SYSTEM	Land occupied by transport infrastructure	1																			
	Cars and two-wheelers per capita					1			1											2	
	Walking and cycling networks	1	1	1		2								3	1					9	
	Public Transport reliability	1	1	1		2								2							7
	Share of active and public transport modes in modal split		2			3					1	3									9
IMPACTS	Access to public transport service		2			3				2	3						1			11	
	Access to transport system for vulnerable groups		3											3						6	
	Access to urban functions (jobs, school, retail, health)	2	3								3			1						9	
	Travel time to work	2	3																		5
	Satisfaction with mobility services		2				2					2									6
	Traffic fatalities [and serious injuries]		3							3		1									7
	Security (crimes in transport) (survey)		2				1														3
	Affordability of transport	2	3										2								7
	Congestion and other externalities [time or costs]	2		1					1				1								5
	Transport system costs to society	2											1								3
	Perceived economic opportunity (survey)	2											1								3
	Transport fuel consumption (model/calculation)	2		2					3										1		8
	Greenhouse gas emissions			3		2	2	2													9
	Air quality (pm10-pm2.5)			3		1	1	1												3	9
	Noise levels			3														1	1		5

Access to public transport service', which is the indicator officially proposed for SDG 11.2 comes out on top even if it is not directly a measure of a transport impact.

For the methodology assessment a 1-3 score was used (no zeroes) and the results summarized for each indicator. Results are shown in Table 10. In this case 'Air quality' comes out on top, closely followed by others. The hardest criterion to fulfill is 'data regularly available or readily produced'.

Table 10. Assessment of indicators according to methodology.

INDICATORS		METHODOLOGY	DEFINITION AND CONCEPTS EXIST	HAS BEEN APPLIED IN PRACTICE IN CITIES	DATA REGULARLY AVAILABLE OR READILY PRODUCED	CLEAR INTERPRETATION	SCALE TO NORMALISE FOR INDEX CAN BE DEFINED	RELEVANT AND ACTIONAL FOR CITIES	JOINT ASSESSMENT
SYSTEM	Land occupied by transport infrastructure	3	3	2	2	2	2	14	
	Cars and two-wheelers per capita	3	3	2	2	2	2	14	
	Walking and cycling networks	3	3	2	3	2	3	16	
	Public Transport reliability	2	1	1	3	2	2	11	
	Share of active and public transport modes in modal split	3	3	2	3	2	2	15	
IMPACTS	Access to public transport service	3	3	2	3	2	2	15	
	Access to transport system for vulnerable groups	2	2	1	3	2	3	13	
	Access to urban functions (jobs, school, retail, health)	2	3	1	2	1	2	11	
	Travel time to work	3	3	1	2	2	2	13	
	Satisfaction with mobility services	2	3	1	3	2	2	13	
	Traffic fatalities [and serious injuries]	3 [1]	3	3 [1]	3	3	3	16	
	Security (crimes in transport) (survey)	2	1	1	2	2	2	10	
	Affordability of transport	2	2	1	2	2	2	11	
	Congestion and other externalities [time or costs]	2	3	1	3	2	3	14	
	Transport system costs to society	2	2	1/2	2	1	2	10,5	
	Perceived economic opportunity (survey)	2	2	1	2	2	1	10	
	Transport fuel consumption (model/calculation)	3	2	1	2	2	2	12	
	Greenhouse gas emissions	3	3	1	3	2	3	15	
	Air quality (pm10-pm2.5)	3	3	2/3	3	2	3	16,5	
Noise levels	3	2	1	3	2	2	13		

Finally, the two sets of scores were summed, giving equal weight to each dimension. The resulting ranking is shown in Table 11.

Table 11. Combined ranking of indicators

Indicators	Score
Air quality (pm10-pm2.5)	177.78
Access to public transport service	176.92
Walking and cycling networks	170.09
Share of active and public transport modes in modal split	154.70
Greenhouse gas emissions	154.70
Traffic fatalities [and serious injuries]	147.86
Transport fuel consumption	97.44
Congestion and other externalities	94.87
Access to urban functions (jobs, school, retail, health)	93.16
Access to transport system for vulnerable groups	90.60
Satisfaction with mobility services	90.60
Land occupied by transport infrastructure	83.76
Travel time to work	79.49
Noise levels	79.49
Public Transport reliability	70.94
Affordability of transport	70.94
Cars and two-wheelers per capita	61.54
Transport system costs to society	18.80
Security (crimes in transport) (survey)	11.11
Perceived economic opportunity (survey)	11.11

Initially eight indicators were identified two for each of the three sustainability domains, and two for transport system features (also indirectly important for all three domains).

The ranked indicator list in Table 11 was reviewed again from the top to check for,

- Balance across the domains
- Feasibility of indicators
- Relevance for cities in the Asia-Pacific region.

This adjustment process led to some changes and choices.

The shortlist indicator 'Walking and cycling networks' was redefined to measure existing urban transport plans in terms of how well they cover the alternative travel modes, including intermodal facilities. It was renamed as 'Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modes'.

The shortlist indicator 'Costs of congestion', was found difficult and problematic to measure due to lack of agreed methodology, even if found very relevant in some references. Instead is used the indicator 'Affordability of transport'. Despite low scores in the subjective assessment, this is an indicator proposed in many studies, with direct relevance for the economic and social domain.

Another economic candidate indicator that scored high, namely 'Transport fuel consumption' was skipped because of overlap with the environmental indicator 'Greenhouse gas emissions'. It was replaced by 'Transport system costs to society' with a definition related to the scale of investments, and renamed as 'Investment in public transportation systems'.

3.3 Final adjustment of indicator set

This draft indicator set was presented at the Expert Group Meeting on Planning and Development of Sustainable Urban Transportation Systems held in Kathmandu on 22-23 September 2016. One of the aims for the workshop was to discuss and propose any needed adjustments to the preliminary selection of indicators proposed.

The experts discussed the proposed indicators with a view to their relevance, feasibility and applicability to urban transport planning in Asian cities.

A main comment was that the performance and operation of the transport systems were not sufficiently represented in the indicator set. System performance is essential for agencies responsible for implementing urban transport plans and strategies, who are to be main users of the index.

The outcome of the discussion was an endorsement of the proposed indicator set with several comments to adjust individual indicators as well as a request to include two additional indicators. Based on the workshop conclusions it was decided to add the two proposed new indicators.

In the 'transport system' domain: '*Quality and reliability of public transport service*'

In the 'Economy' domain: '*Operational costs of the public transport system*'.

Moreover, it was proposed to dissolve the rigid allocation of each indicator to one domain since some indicators relate to several domains.

The final set of indicators is shown in Table 12, indicating how each one fits in the SUTI framework.

The revised final set of indicators were presented at the Regional Meeting on Sustainable Urban Transport Index held in Jakarta on 2-3 March 2017. The Meeting agreed to the finalized SUTI that included ten indicators covering system, economic, social and environmental dimensions of urban transport system and services.

Table 12. Final set of indicators for assessment of urban transport

No.	Indicators	Dimensions	Strategies	SGD Targets
1	Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modes	System (Environmental/Social)	Shift	(11.2)
2	Modal share of active and public transport in commuting	System (Environmental/Social)	Shift	(11.2)
3	Convenient access to public transport service	Social	Shift	11.2
4	Public transport quality and reliability	Social	Shift	11.2
5	Traffic fatalities per 100,000 inhabitants	Social	Improve	3.6
6	Affordability – travel costs as part of income	Environmental/Social.	Improve	(11.2)
7	Operational costs of the public transport system	Economic	Shift/Improve	(9.1)
8	Investment in public transportation systems	Economic	Shift	(11.2, 9.1)
9	Air quality (PM10)	Environmental	Avoid/Shift/Improve	11.6
10	Greenhouse gas emissions from transport	Environmental	Avoid/Shift/Improve	(7.3, 13.6)

It can be noted that the indicator set has its strongest focus on the social dimension, the shift strategy, and especially SDG target 11.2 “Access to safe, affordable, accessible and sustainable transport systems for all”. This seems fair, since Target 11.2 is the SDG target designated for the urban transport field in the full SDG set, and since it reflects the results of the expert consultation, emphasizing current issues of relevance for urban transport planners, practitioners, and decision makers in Asian cities.

If this goal is fulfilled in an effective way, using the proposed indicators it will likely also support the achievement of other dimensions in the framework, including environmental and economic objectives. By this adjustment a rigorous ‘domain’ approach is also abandoned. Key domains and dimension of sustainability are addressed (as seen in Table 12). In addition to widening the indicator set some additional adjustments have been made.

For most other indicators additional information has been added regarding collection and using data to produce the indicator, and regarding possible alternative specifications of the indicator.

4. Description and Refinement of Selected Indicators

This chapter provides definitions, metrics and other details of the ten indicators in the final set. The chapter will thereby provide specific guidance to support the collection of data for the indicators, measuring them, and producing the index.

For each indicator, the following elements are described:

- Indicator relevance for sustainable transport and the framework elements.
- Proposed definition.
- Unit of measurement.
- Interpretation regarding sustainable transport.
- Minimum and maximum values of indicator scale to use in the index construction.
- Sources in the literature.
- Comments on data availability and methods to provide data.
- Other comments.

The purpose of each element is described in the following.

Indicator relevance for sustainable transport and the framework elements

This element explains why the topic and indicator is relevant. It is drawn from the framework presented in chapter 2. It provides the overall justification for including each indicator in the SUTI.

Proposed definition

A specific definition of what is measured. In most cases the definition is drawn from literature where the indicator has been proposed and presented. Often different definitions exist in the literature. In that case the definition deemed most suitable for SUTI is used. In some cases, the indicator is defined especially for the context of the SUTI.

Unit of measurement

The metrics needed to actually measure and report the indicator (e.g. 'number of traffic fatalities per 100.000 inhabitants per year').

Interpretation

Two aspects are considered here,

- a) whether the indicator has a clear interpretation regarding sustainable transport or is more ambiguous. Only indicators with quite clear interpretation are included.
- b) the direction of change of the indicator that is positive and negative, respectively. For example, it is clear and unambiguous that declining emissions are positive, so lower emissions are more sustainable. The direction for each indicator also matters for calculating the index.

Minimum and maximum values to use in the index construction

To build the normalized index it is necessary to use a common scaling for all indicators. For the SUTI it has been decided to normalize indicators on a scale 0-100 as will be explained in chapter 5.

Goal posts' in terms of what constitute '0' or 'minimum' and '100' or 'maximum' values need to be defined.

For each indicator '0' or 'minimum' is understood as the poorest performance of an indicator in a city in practice, whereas '100' or 'maximum' is considered the best value in practice. So 'minimum' does not necessarily mean lowest numerical value (for example a low numerical value is desirable in the cases of fatalities and emissions), and vice versa for 'maximum'.

Values for 'minimum' and 'maximum' are derived from literature that reports on what can be considered as the worst and best- case scenarios for cities in Asia (if data were found) or around the world (if not). It is relevant to apply such values for the scale to provide similar kinds of complete and realistic scales for each indicator. If a scale is not reflecting a complete and realistic range the comparison across indicators could be distorted. For example, if 'maximum' value for some indicator were set by an ideal goal far above what is realistic, all cities would perform almost equally poor for this indicator, and the difference among cities would be almost eliminated for this indicator.

However, the precise definition of the 'minimum' – 'maximum' scale is not necessarily that critical to results. As long as the scales are fairly comparable, the ranking among cities will not be affected too much. The tables per indicator explain the choice of 'minimum' and 'maximum' values. In a few cases indicators 'minimum' and 'maximum' are not defined in literature but in a different way, as will be described.

Sources in the literature

This refers to key sources that have been used to identify and define the indicator.

Data availability, methods to provide data, and examples

This section offers qualitative comments about expected data availability and related issues.

Also comments on methodologies and examples on how to possibly collect or provide data for the indicator are offered. Please note that the report does not provide detailed reviews of data sources or data availability as this was outside the scope of the project.

Other comments

This address possible limitations of the proposed indicator and some possible alternatives regarding definition, measurement, delimitation, etc. This is to help inform the use of the indicator and any further work.

4.1 Indicator 1: Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modes

Relevance

According to most studies and policy documents it is an essential element in urban sustainable transport planning to provide for alternatives to motorized individual transport including public transport, walking, and cycling. Urban transport plans should reflect this ambition explicitly.

The indicator refers directly to SDG target 11.2 “By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all”. It is also relevant for SDG target 9.1 “Develop quality, reliable, sustainable and resilient infrastructure”.

The indicator refers to the ‘Shift’ strategy in the sustainable mobility paradigm.

The indicator relates more indirectly to the three dimensions, ‘Economy’, ‘Society’, ‘Environment’, which is also the case for all other ‘system’ domain indicators. Transport planning for these modes can lead to reduced impacts in all three domains, but is not directly guaranteed to do so.

Definition

The extent to which the city’s most current comprehensive transport policy or master plan covers the four aspects I) walking networks, II) cycling networks, III) intermodal transfer facilities and IV) expansion of public transport modes.

Unit

The extent is measured on a qualitative scale from 0 to 4 for each of the four aspects and aggregated across aspects to provide a single score from 0 to 16 for the city’s transport plan. The unit is therefore a discreet numerical scale 0-16 based on a qualitative assessment of the city’s plan.

For each of the four aspects I – IV, the extent of the coverage in the plan should be reviewed and scored on a 5-step scale:

- 0) No coverage of the aspect
- 1) Limited coverage of the aspect
- 2) Middle coverage of the aspect
- 3) Extensive coverage of the aspect
- 4) Leading coverage of the aspect

The scores for all four aspects are then added together to provide the overall score. The minimum score will therefore be 0 (=the case that none of the four aspects are covered at all). The maximum score is 16 (the case that a city is a regional leader in all four aspects, 4X4).

An example of how to conduct such a review is given in the section below on ‘Data availability and methods to provide data’.

Interpretation

Clear-cut. Increasing score is always positive.

Minimum value

0 meaning the urban transport plan does not cover any of the four transport options.

Maximum value

16 meaning the urban transport plan covers all options to the highest degree; the city is leading.

Comment to Minimum-Maximum

The minimum-maximum values for this indicator have been set specifically for this study as the theoretically possible minimum and maximum. It is unlikely that a city transport master plan will offer absolutely no coverage of any of the four aspects (score 0). It is also somewhat unlikely that a city plan can represent leading coverage within all the four aspects. When the indicator has been tested in practice it may be feasible to revise minimum and maximum and set more realistic signposts (e.g. scores between 4 and 12).

Sources in the literature

The approach is similar to the categorical measures used for assessing policies and plans used in the European Eco-Mobility Shift project (Kodukula 2013), and the Korean SUTE framework (KOTI 2015). Because the precise indicator as defined here does not exist in literature before, there is no source with exactly the similar methodology. Methodology guidance is proposed in section below.

Data availability, methods to provide data, and examples

Data are not immediately available. Data needs to be produced for each city based on an assessment of the content of the latest urban transport plan for the city. The assessment could be done by an expert panel reviewing the city's latest adopted master plan document covering transport and supporting documents. The panel could be local experts or involve peer review with others.

The following guidance is offered to apply this method for collecting data from the review of the plan. The assessment considers the four aspects one by one (i) walking infrastructure; (ii) cycling networks, (iii) intermodal transfer facilities, and (iv) expansion of public transport modes.

For each aspect the question is: How well does the plan cover this aspect? A transport plan can basically cover each aspect by three types of action as can be detected in a plan document,

- 1) **Stating clear goals and visions for each aspect.** Visions, goals, objectives and targets are key components of a plan, and useful to demonstrate commitment to sustainable transport. Goals are stronger if they are quantified and accompanied by a performance monitoring process. For example. 'The City will make cycling a more attractive option for short trips' (less clear goal = limited coverage for cycling aspect). Or 'The City will increase the modal share of public transport from 25 to 40 per cent the share of walking and cycling from 20 to 40 per cent, and limit individual motorized transport from 55 to 20 per cent by 2030 – this will be monitored on an annual basis' (clear quantitative goals, extensive coverage for three of the four aspects)
- 2) **Designating infrastructure, facilities and measures for each aspect in the plan.** A transport plan usually identifies projects and measures to be adopted, described and shown on maps and tables. The extent of the designation is important as well as the level of detail. For example: Dedicated cycle lanes are planned along one of the city's main transport corridors (limited effort, low coverage of cycling). Or: City building three new intermodal terminals to connect rail and bus services in the city, and will reroute bus lines to serve these terminals optimally, with detailed assessment of impacts (strong effort, extensive coverage).

- 3) **Allocating funding, specifying budgets, securing finance for the facilities.** A plan needs investments and may involve running costs for new transport operations or services. Some budget may be local (tax, revenues), other parts may be from central government, lending institutions, or innovative finance schemes. A budget can be more or less secured. For example: The City plan does not mention any budget for facilities for cyclists in its plan (no coverage of this action for cycling aspect) Or: The City will allocate X amount to construction of the cycle lanes needed for a fully connected cycle lane network, which means a 200% increase of the budget for cycle facilities over the next 5 years, which have been secured by a development bank credit, a city council budget decision and revenues from a parking charge (strong commitment, extensive coverage of this aspect)

Assessing the combination of the three types of action together allows a more solid review. For example, if ambitious goals for cycling are included in a plan it is positive, but the plan should score lower if the plan does not actually designate projects to secure cyclists and no budget is committed. There should be a balance between goals, designations and budget at each level.

Table 13 provides a rough guideline for allocating scores to the various aspects of an urban transport plan based on these directions. This is only a highly indicative suggestion, as many combinations are possible.

Table 13. Indicative outline of scoring criteria

	Score				
	0 No coverage	1 Limited	2 Middle	3 Extensive	4 Leading
I) walking networks	No goals No designation No budget	Vague goal Little designation seen in plans Small or unclear budget	Qualitative goals Some designation in 1-2 major areas/corridors Some budget	Quantitative goals Much designation across city increased realistic budget	Ambitious goals Full designation across city Major secured new funding
II) cycling networks	No goals No designation No budget	Vague goal Little designation seen in plans Small or unclear budget	Qualitative goals Some designation in 1-2 major areas/corridors Some budget	Quantitative goals Much designation across city Increased realistic budget	Ambitious goals Full designation across city Major secured new funding
III) intermodal transfer facilities	No goals No designation No budget	Vague goal Little designation seen in plans Small or unclear budget	Qualitative goals Some designation in 1-2 major areas/corridors Some budget	Quantitative goals Much designation across city Increased realistic budget	Ambitious goals Full designation across city Major secured new funding
IV) public transport	No goals No designation No budget	Vague goal Little designation seen in plans Small or unclear budget	Qualitative goals Some designation in 1-2 major areas/corridors Some budget	Quantitative goals Much designation across city Increased realistic budget	Ambitious goals Full designation across city Major secured new funding

It is not possible or useful to specify a complete detailed assessment framework with extensive scoring criteria for all combinations of aspects and types of action. This is because the context for each city is different and the kind of plans and commitments depend on city topography, history, culture etc. Each plan is unique. We cannot define e.g. how much budget commitment is needed for a cycling budget to be 'extensive' or 'leading' or how clear goals must be formulated to shift from 'limited' to 'standard'. A complete framework would be too rigid, work-intensive, and have strong risk of bias. It will be the task for an expert review team to take relevant details of the plan into account as much as possible when reviewing and scoring the plan. However, a uniform scoring framework as proposed here should be helpful. This is a somewhat similar approach as taken in the 'Policy evaluation' section of the SUTE framework used in the Republic of Korea, where an expert panel with insight in plans conducts a professional assessment of each plan along certain criteria.

It is recommended that,

- the scoring will consider each of the four aspects one by one
- the scoring for each aspect considers if the plan has from 'Zero' to 'Leading' coverage for each aspect using the scale 0-4 to score accordingly
- when scoring for coverage then consider: a) goals and visions: b) extent and quality of facilities and measures included in the plan: and c) budgets committed to the plan to the extent possible and relevant.
- Score for each of the four aspects are added to form a single score 0 – 16 for the indicator.

Further comments

The proposed scoring method is an example. Further elaboration may be relevant as part of practical testing of the SUTI. Some issues to consider before using the indicator as part of SUTI include the identification of the most appropriate/comprehensive current plan to evaluate (as several partial plans may exist) and the need to designate an expert team or other persons to review and score the plan. A procedure and protocol for the review team should be defined.

It is also possible to consider if it should be allowed by the expert team to weigh any of four aspects (cycling, walking, intermodal facilities etc.) higher than others, depending on the topography, history or other context of the city.

Box 2 illustrates a case of hypothetical city to evaluate and score urban transport plan.

Box 2: Hypothetical example to evaluate 'City X' urban transport plan

City X plan has low attention to and coverage of walking. It has no vision or goal for the role and priority of pedestrians in the city's transport system. It only includes a small number of pedestrian facilities (for example 500 m of new sidewalk, pedestrianization of one minor square, introducing two new pedestrian crossings), and it does not state how much funding is needed for these facilities.

Walking Score: 1

City X plan has low coverage for cycling. It mentions that cycling is used as a mode of transport, but does not specify goals to enhance cycling safety and comfort or share of bicycles in the modal split. The plan will provide a stretch of cycle lane on three of 10 main arteries in the city but does not mention improved cycle parking facilities anywhere or provisions to give cyclists improved rights in traffic. The city does not state how much funding is needed for the planned facilities.

Cycling Score: 1

City X plan has extensive coverage for public transport. It introduces a long-term strategy for a BRT system with feeder lines, supplemented by significant modifications to the street network and signaling to give BRT priority throughout the network, plus other supporting measures. The impact of the BRT has been assessed regarding transport volumes, impacts on vehicle flows, congestion and emissions but only after completion, not during the implementation stages. The long-term strategy is divided into phases, with first a 5-year stage being planned in detail spatially and timewise. There is a goal that public transport will carry 30 per cent of the city's traffic when the plan is fulfilled and specific intermediate goals for passengers carried on the BRT. The plan has secured funding for first phase from a bank, the national transport ministry and the city budget based on a local tax that is awaiting the result of a referendum for approval. There is also indicative commitment for the full plan from funders. Coverage of public transport is extensive. Public transport Score: 3.

City X plan has some coverage of intermodal transfer facilities. Although the plan is called 'a multi-modal strategy' with bus feeder lines mentioned in the BRT plan and connection nodes appointed there are no details on how the connections are to be designed and secured. The plan does include a BRT connection to the exiting long-distance bus station, but the interchange is not designated in the plan or included in the budget. There is a goal to encourage bicycles as feeders, but no facilities or budgets for interchange between cycling and BRT e.g. in the form of secured bicycle parking at nodes. Mention of the rail station area as a future intermodal transfer point with a detailed project under way. Intermodal Score: 2

Total score: 7 out of 16.

4.2 Indicator 2: Modal share of active and public transport in commuting

Relevance

To monitor the modal split is an essential element in providing sustainable urban transport.

The indicator refers to SDG target 11.2 “By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all”. Active and public transport may be considered as more sustainable transport compared to individual motorized transport.

The indicator refers to the ‘SHIFT’ strategy in the sustainable mobility paradigm

Definition

Percentage of commuters using a travel mode to work other than a personal motorized vehicle. ‘Other than personal motorized vehicles’ would include public transport (bus, tram, rail), cycling, and walking.

The indicator definition is not modal split per se, but the share of active and public modes within the split, which is easier to interpret and scale.

Unit

Percentage of trips for commuters not by personal motorized vehicle

Interpretation

Clear-cut. Increasing is positive.

Minimum value

10 per cent

Maximum value

90 per cent

Comment to Minimum-Maximum

Collected from a review of different sources. No cities in Asia appear to report less than 10 per cent non-motorized and public transport. Highest reported is around 90 per cent (Hong Kong, China according to Arthur D. Little (2014)).

Sources in the literature

The definition for this indicator is drawn from GCIF (2015) using the ISO 37120 standard set of indicators, also applied in the World Bank Report on Urban Transport Benchmarking (Henning et al. 2011). There are numerous other references providing definitions and variations of the modal split indicator, including; Rye and Stanchev (2016); Arthur D Little (2014) and others.

Data availability, methods to provide data, and examples

Most cities consider modal split data. The methodology to measure modal split often differ, but the ISO 37120 standard could be the common basis. The best source of data is a regularly updated travel survey at the local level. The travel survey would ask citizens about their travel to work, one a particular day, or (more accurate) over a period of five days, which is averaged.

According to Rye and Stanchev (2016) a lower cost but also less accurate alternative compared to a household survey is to conduct visual counts of pedestrians and vehicles (bus, car, van, 2-wheeler, bicycle) and their occupants across a cordon or line. This should be done at least once a year.

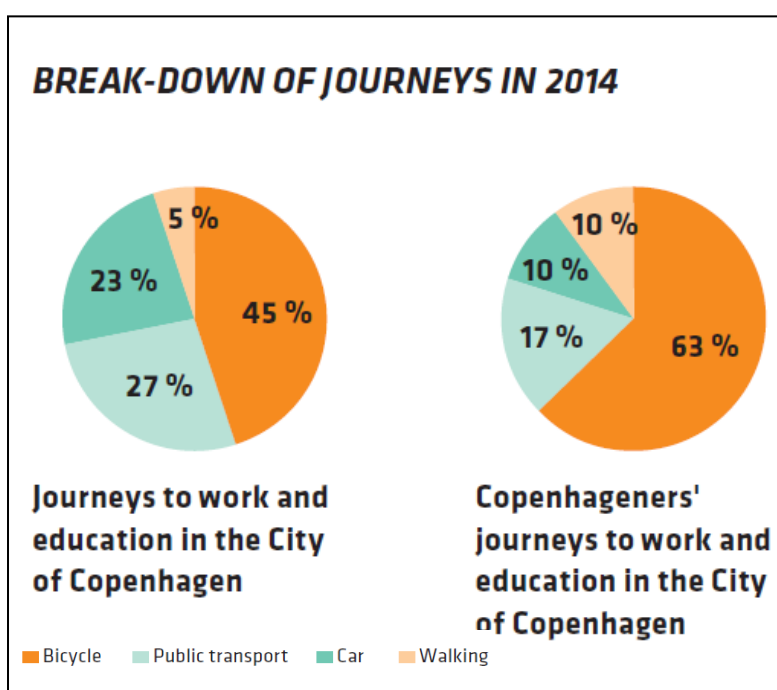
If restricting such counts to the peak hour traffic a proxy of commuting shares can be obtained.

While not complete such data can help to monitor trends over time in modal split, and the relative share of the active and public modes.

Many cities use modal split as a target by which to measure the success of their mobility policies.

Figure 1 shows an example from the City of Copenhagen, Denmark which extracts data for modal split in Copenhagen from a regional sample of the ongoing Danish National Travel Survey to monitor results of their environmental policies as well as their cycling strategy. The account is provided for all commuting trips with origin/destination in the city as well as for Copenhagen city dwellers only. The city can thus benefit from the detailed national travel survey, for which it pays part of the costs.

Figure 1. Copenhagen public transport share, 2014



Further comments

Different definitions and methodologies to generate the modal-split based indicator across cities will obviously limit cross-city comparisons, although not so for time series within a city, if the same method is used.

The unit used here is trips but it would be preferable to calculate modal split by passenger-km, which is more useful for also calculating other indicators such as emissions. However, this would require a survey which also covers trip distances, which adds burdens to the data collection.

4.3 Indicator 3: Convenient access to public transport service

Relevance

Access to public transport is a key requirement for equitable access in a sustainable city.

This is the main indicator adopted by the Un Statistical Commission for monitoring SDG target 11.2 “By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all”.

The indicator refers directly to the ‘Shift’ strategy in the sustainable mobility paradigm.

It is relevant for the social dimension of ‘People’

Definition

Proportion (percentage) of the population that has convenient access to public transport, defined as living 500 meters or less from a public transport stop with minimum 20-minute service.

Public transport is a shared passenger transport service available to the general public, excluding taxis, car pools, hired buses and para-transit (ideally the measure is disaggregated by gender, age group, and persons with disabilities).

Unit

Percentage of population.

Interpretation

Clear-cut. Increasing is positive.

Minimum value

20

Maximum value

100

Comment to Minimum-Maximum

WBCSD (2016) defines minimum and maximum as 0 per cent and 100 per cent for this indicator. However, 0 per cent meaning all transport would be by individual motor transport is unrealistic and not observed in any city. 20 per cent is a more realistic lower value for cities where data are available. 100 per cent is also not observed but some cities are very close (above 95 per cent).

Sources in the literature

Habitat (2016); WBCSD (2016); CIVITAS (2016), and others.

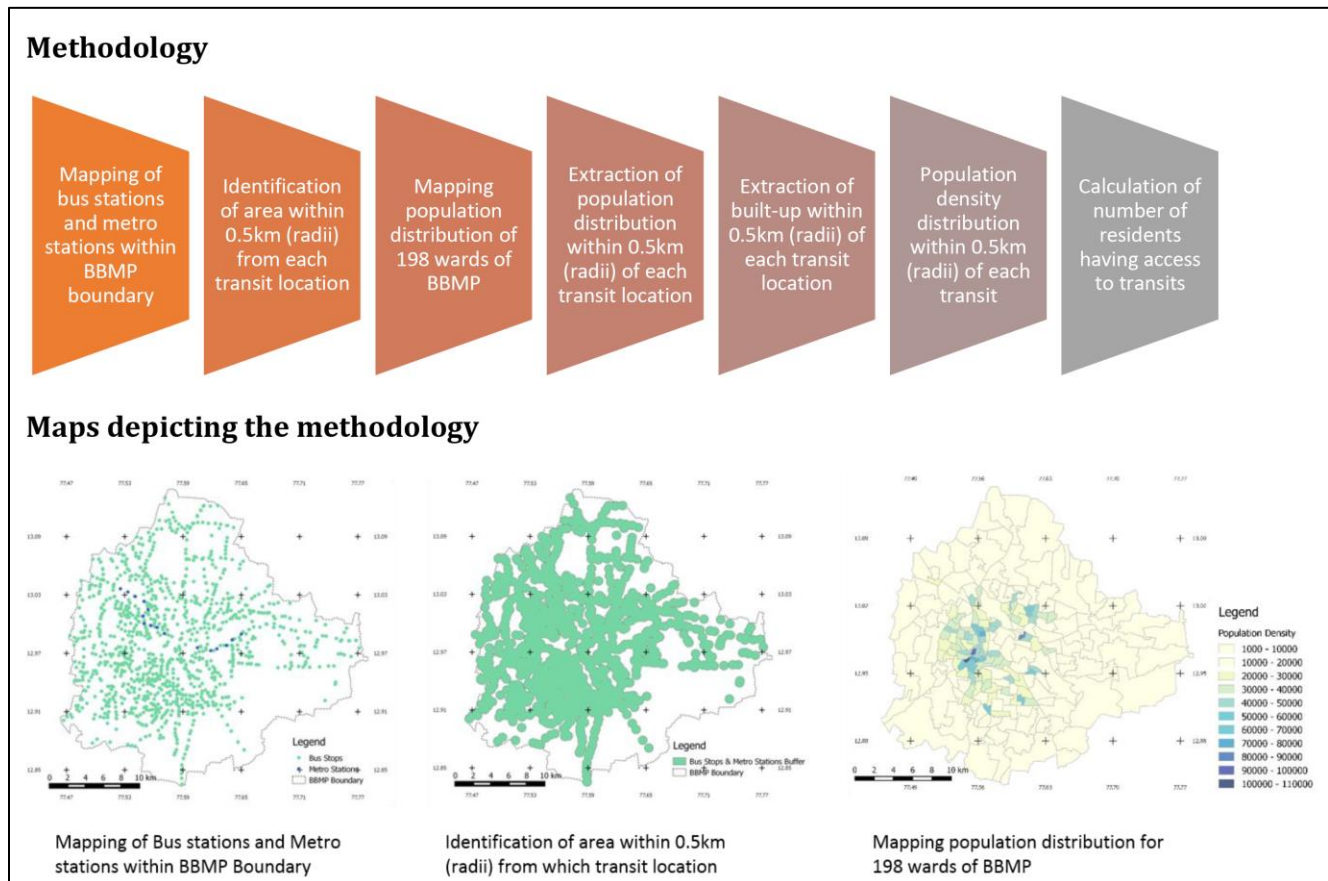
Data availability, methods to provide data, and examples

The indicator may not be directly available in most cities. It is simple to make crude estimates of the data at city level. It is straightforward to map public transport routes and their stops across a city, which can even be done manually. A 500-m radius around each stop can be drawn on a map (buffer zone). The population density in each buffer zone may be derived from neighborhood or city quarter population figures. This allows calculating the population within each zone. Adding the population in all buffer zones gives the total. Obviously more accurate and reliable results can be provided if network and population data are stored as geographic information in a GIS database as detailed level.

The indicator has been applied in several cities, including Bangalore, Bangkok, Chengdu and Mumbai.

Figure 2, shows an example from a project in Bangalore, which had the aim to measure and report a set of indicators for several SDGs and targets, including Target 11.2 on sustainable urban transport. In this case 3.6 million or 42 per cent of inhabitants were found to live within the combined 500 m buffer zones (Mistra 2015).

Figure 2. Data process for city of Bangalore for SDG target 11.2 indicator



Further comments

It is possible to consider different ways to measure the 500-m distance (crow flight, actual walking distance, time used etc.). More sophisticated measures can provide more realistic assessment. It would also be a possibility to differentiate between stops according to quality of service (e.g. larger buffers around rail stations (1 km) than bus stops (500 m)) or according to frequency of services at the stop. The indicator does not fully reflect all aspects of the SDG target 11.2 which speaks of i.e. 'safe', 'affordable', 'accessible' and 'sustainable' (Habitat 2016). Some of these attributes are only indirectly covered by the indicator, unless one considers public transport to be inherently safe, affordable, and sustainable. Habitat (2016a and b) discuss some possible additional indicator for the target 11.2.

4.4 Indicator 4: Public transport quality and reliability

Relevance

Providing high quality service in urban public transport is essential for attracting more passengers and limiting individual motorized transport in the long term. High share in public transport modes supports urban sustainability including the economy. Focus on quality and reliability may help for example bus companies attract more riders and improve their financial performance as well as the urban transport flow (Trompet et al 2011; Liu and Sinha 2007).

Many measures of public transport quality exist. It is difficult to fully describe and measure all important aspects of public transport quality in simple and objective terms, or using only one indicator. Both objective and subjective indicators can be used to measure quality (Henscher 2015).

An important objective indicator is the reliability of the public transport system. This is often referred to as one of the most critical elements in service quality. Reliability is typically measured in terms of deviation in time from scheduled services, such as percentage of services arriving or departing more than x minutes late. Another critical aspect is variability (van Oort 2014). It is unattractive for customers to experience unpredictability due to variation in reliability, even if the average deviation is the same

The user's positive subjective experience of the service is critical for people's desire to choose public transport (Beirao et al 2007). Monitoring the subjective *user satisfaction* is therefore becoming a widespread approach among urban public transport companies in the world. User satisfaction can cover several aspects, including factors like punctuality, cleanliness and connectivity. Monitoring satisfaction on a regular basis can give insights for the passengers' experience while using public transport services and help point out areas for improvement. Measuring satisfaction using a passenger survey can be a simpler approach than setting up a system to accurately measure and represent objective reliability of an urban transport system.

The recommended indicator is therefore a measure of user satisfaction. Additional objective indicators on reliability are described as possible supplements or alternatives in the section below on 'Further comments'.

This indicator relates to the social dimension of 'People'. It is relevant for monitoring SDG target 3.2 "By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all" and for target 9.1 "Develop quality, reliable, sustainable and resilient infrastructure". It is important for the "Shift" strategy in the sustainable mobility paradigm.

Definition

The degree to which passengers of the public transport system are satisfied with the quality of service while using the different modes of public transport.

Unit

Overall share of satisfied customers as percentage of all public transport users (per cent) based on a survey.

Interpretation

Clear-cut. Increasing score is always positive.

Minimum value

30 per cent

Maximum value

95 per cent

Comment to Minimum-Maximum

Minimum-maximum are defined based on review of studies including de Oña and de Oña (2015), as well as quality reports from public transport companies or cities, including Singapore (for maximum value), Indore, Greater Wellington, and the United Kingdom NHT public satisfaction survey (a website covering public transport user satisfaction for all United Kingdom cities and towns). Due to different methodologies applied by many public transport companies/cities, and lack of a comprehensive database for Asian cities the minimum-maximum range can be seen a preliminary. The range may have to be adjusted as the indicator is applied.

Sources in the literature

The German technical aid organization GIZ provides a condensed summary of various approaches in their report on 'Measuring Public Transport Performance' (found at <http://www.sutp.org/en/>).

The eight categories used to survey satisfaction for the SUTI indicator were ones highlighted in the study by de Oña and de Oña (2015), as among those most the most commonly applied in this context. The reference also offers a review of the history of service quality measurement.

Eboli and Mazzulla (2009) provide an even wider account of different quality factors that have been or potentially could be addressed in public transport user satisfactions surveys. A similar effort for inspiration can be found at <https://nhtsurvey.econtrack.com>.

Data availability, methods to provide data, and examples

Satisfaction survey data may be available on a regular basis from some local public transport companies or regional agencies, but often only for major cities and/or for major operators like metros. In many cases there is no survey or only partial survey (for some company out of several).

The suggested approach is to conduct (at least) annual survey of public transport users, on board the city's' public transport systems. The survey should cover satisfaction with key elements of relevance to users that is aggregated into one score for satisfaction per system or city. The survey should thereby produce an indicator of satisfaction from the users of public transport to a scale of 0-100.

The satisfaction elements may vary as there is no uniform agreement on which factors matter most for users. The following can be considered as a minimum guidance for questions:

- Frequency of the service
- Punctuality (delay)
- Comfort and cleanliness of vehicles
- Safety of vehicles
- Convenience/safety of stops/stations,
- Availability of information
- Personnel courtesy
- Fare level

More comprehensive lists of items can be found in for example Eboli and Mazzulla (2009) and at <https://nhstsurvey.econtrack.com>

It is standard to conduct survey using a Likert scale (either 5 or 7 step) to score satisfaction for each question. For example, as used by New South Wales Government in Australia is shown in Figure 3.

Figure 3: Example of a seven-point Likert scale for satisfaction survey

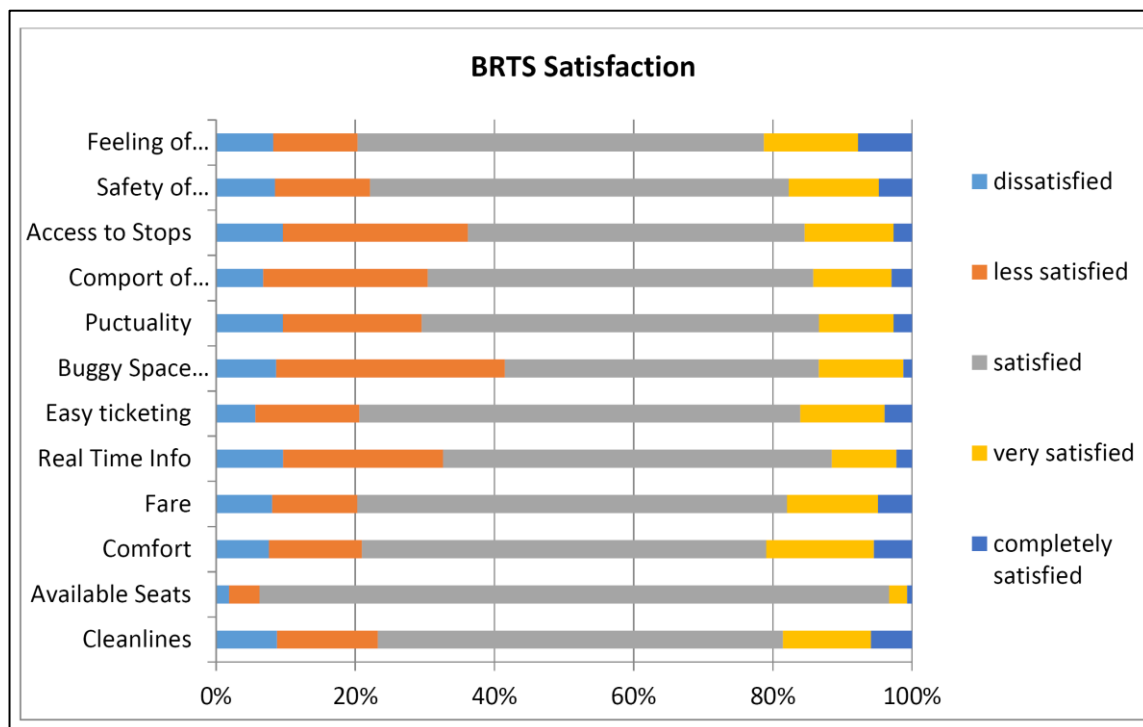
Dissatisfied				Satisfied		
1	2	3	4	5	6	7
Very Dissatisfied	Dissatisfied	Partly Dissatisfied	Neither Satisfied nor Dissatisfied	Partly Satisfied	Satisfied	Very Satisfied

The SUTI indicator is derived by summing up the answers with a positive satisfaction. It is important to define clearly which categories count in the ‘satisfied’. High numbers in satisfaction (in the 85-95 per cent range) can typically only be obtained by adding all three tops levels 5-6-7 on a 7–step scale).

In the case of different modes of transport are used the answers should be weighted with respect to the amount of transport users or trips (the sample size is adjusted as well).

Figure 4 shows an example of reporting user satisfaction for BRT system in city of Indore in India (WBCSD 2016b).

Figure 4. User satisfaction survey for BRTS in Indore city using 5-step scale



Further comments

With regard to **subjective satisfaction** there are other ways to register it than by passenger surveys.

(a) One is to include questions on satisfaction with public transport service in a general household survey if such exists. An advantage of this method is the possibility to include *potential* users of public transport and people with restricted mobility. This method also can ensure anonymity if this is desirable.

(b) Installation of a device (Figure 5) with 3 or 4 buttons of satisfaction indicating the pleasure of trip. This device can be installed on-board, at waiting areas such as stops, stations, platforms and can be moved around across different modes after an adequate number of answers is collected. This method is not so accurate and comprehensive with only one attribute representing the service quality of public transport. Therefore, it will not indicate areas of improvement if dissatisfaction occurs. A greater number of responses are necessary to have more reliable results. This method is less costly and ensures anonymity as well.

Figure 5. Customer satisfaction survey device



Another option as mentioned before is to use **objective measures for reliability**.

Many possible objective indicators for reliability exist and there is limited consistency in their usage (van Oort 2014; Trompet et al 2011). Three of the most common are on-time performance, headway regularity, and the adherence to running time (Eboli and Mazzullo 2012). One of the most advanced measures to reflect passenger experience is the Excess Wait Time used by Transport for London (van Oort 2014). It is expressed as the difference between Scheduled Wait Time (e.g. average 5 minutes for 10-minute headway) and Actual Wait Time.

Which measures are most useful depend on factors like service frequency and data availability. For highly frequent services (10 minutes headway or less) where schedules do not matter so much, the most typical measure is deviation from scheduled headway between services. For less frequent services the deviation (delay) from scheduled arrival/departures is more relevant.

In practice, the most frequent measure for urban bus companies is some form of wait assessment in absolute time, for example the percentage of departures within a threshold of less than 5 minute after schedule. Wait assessment is intuitive and easy to communicate, but does not consider the extension of a delay beyond the threshold (e.g. if bus is 6 or 15 minutes delayed).

The specific thresholds used differs among cities and regions (typically between 1 and 5 minutes), and some cities also consider earlier departure (for example more than one minute) as irregular.

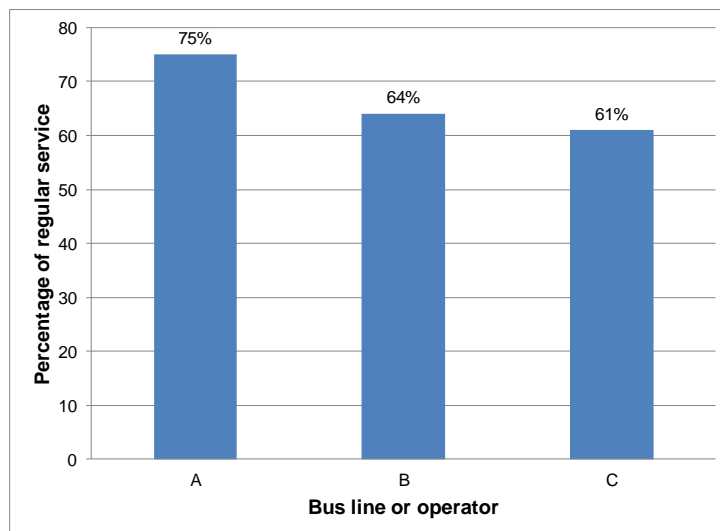
The simplest is method using wait time at one single stop for a single line as indicator. The validity of the indicator will be low. The ideal will ideal is to include all stops for all lines. This will require extensive data collection.

One suggestion for a common measure could be to follow the IBBG bus benchmarking study reported by Trompet et al (2011). This study was based on the following sampling approach for each city:

- The three busiest high-frequency bus routes, with a headway less than 12 minutes
- Actual and scheduled arrival times (minutes and seconds) for one mid-route stop per route,
- Measurement in 2 hours of the morning peak service period,
- Measuring over 5 weekdays in the spring season with no holiday or special event,
- Using 2 minutes delay as fixed threshold.

Figure 6 illustrates hypothetical result of wait assessment (2 min) for regularity performance for three high-frequency bus lines in a city, based on Trompet et al. (2011). An aggregate result could be obtained simply averaging over the three lines, or more accurately by weighing by the passenger volume per line.

Figure 6. Example of wait assessment indicator of bus service



4.5 Indicator 5: Traffic fatalities per 100,000 inhabitants

Relevance

Traffic accidents are a leading cause of death among younger population groups in some countries and are therefore a critical element in public health. The number of fatalities indirectly indicates also the (far more frequently occurring) injuries, as well as substantial health and material costs.

Refers to the social and economic dimensions, 'People' as well as 'Prosperity'.

This is the main indicator to be adopted for directly monitoring SDG target 3.6 'By 2020, halve the number of global deaths and injuries from road traffic accidents'.

Definition

Fatalities in traffic (road; rail, etc.) in the urban areas per 100,000 inhabitants. As defined by the WHO, a death counts as related to a traffic accident if it occurs within 30 days after the accident.

Unit

Number of persons

Interpretation

Clear-cut, Decreasing is positive

Minimum value

35

Maximum value

0

Comment to Minimum-Maximum

WRI (2016) reports fatality data for some selected cities worldwide with worst case of an Asian city being Chennai with 26.6. However, some cities may have higher values, since even higher levels (up to 35) are reported for entire countries like Thailand and the Islamic Republic of Iran (WHO 2015). Therefore, the minimum (worst performance) is set at 35.

Best performing (Max) cities in the world are close to 0, and several cities aspire to this level.

WBCSD (2016) also use 35 and 0.

Sources in the literature

WHO (2015); WRI (2016), WBCSD (2016) et al.

Data availability, methods to provide data, and examples

Most cities collect information on fatal traffic accidents. WHO maintains and updates database over traffic fatalities in member states based on annual national reporting. Some data is available at city level, although not universally (WRI 2016). The updated version of UITP 'Mobility in cities' database appears not to collect accident data.

The International Transport Forum (ITF) hosts the initiative "Safer City Streets" (<http://www.itf-oecd.org/safer-city-streets>) where member cities report and compare traffic safety information. This may be an emerging source of data.

Further comments

Injuries are mentioned as well in the target, but the definition and data collection is not as standardized and comparable as for fatalities. To enhance focus on vulnerable groups such as children, data could be collected for such groups particularly, as proposed/applied in some versions of this indicator.

Could be limited to *road* fatalities if data for other modes are missing or insignificant.

4.6 Indicator 6: Affordability – travel costs as part of income

Relevance

Transport costs represent a significant share of the household budget, especially for low income households. High travel costs can also increase the costs of labor to business. Affordability is a commonly recognized feature of a sustainable transport system.

Relates to the economic as well as the social dimension.

Refers to SDG target 11.2 “By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all”.

Relates to the social and economic domains, ‘People’, and ‘Prosperity’.

Definition

Cost of a monthly network-wide public transport ticket covering all main modes in the city, compared to personal monthly income

Unit

Percentage of monthly income

Interpretation

Clear-cut Decreasing is positive

Minimum value

20

Maximum value

3.5

Comment to Minimum-Maximum

The range is based on WBCSD (2016) which have found these values representative of low and high performance, with 20per cent being a very significant proportion of income allocated to transport.

Sources in the literature

CIVITAS (2016), WBCSD (2016); Arthur D Little (2014) et al.

Data availability, methods to provide data, and examples

Affordability data should be fairly easy to produce locally. Income data for the population is likely available in statistical database, at city or if not at regional level. Cost of a network ticket is simple to obtain. If no network-wide multi-modal ticket exists in a city it should be ticket for largest part of the network.

Not available in global or regional databases generally. Data need to be produced locally, but no survey is needed.

Further comments

It can be argued that the indicator should be designed to reflect more directly the affordability for lower income groups than is the case for the proposed definition and unit, which refer to average population and income.

WBCSD (2016) proposes a more elaborate but still relatively simple definition based on the income of the poorest quartile of the population, for which the share of the income is more critical. The WBCSD also uses an average of 60 public transport tickets rather than 1 monthly pass as network wide cards may not be available in all cities.

It can also be considered to compare the price of network ticket or card with the national minimum wage rather than average income. Minimum wages are applied in about 90 per cent of countries in the world (ILO 2010).

Arthur D Little (2014) applies a *ratio* between the public transport ticket price, and the price for commuting by car, thus indicating the relative 'financial attractiveness' of public transport compared to car.

4.7 Indicator 7: Operational costs of the public transport system

Relevance

The operational costs of the public transport system are critical for the ability of a city to provide affordable, efficient and competitive transport services. The cost can be related to the revenue generated from fares to indicate financial sustainability.

Relates to SDG target 11.2 "By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all".

Relates to the economic dimension of sustainability (financial).

Related to the Shift strategy.

Definition

Ratio of fare revenue to operating costs for public transport systems ('Fare box ratio')

Unit

per cent of operational costs recovered by fares

Interpretation

Clear – Increasing is positive (see further comments below)

Minimum value

22 per cent

Maximum value

175 per cent

Comment to Minimum-Maximum

The minimum-maximum is based on a range of values reported for Asian cities in the International Union of Public Transport (UITP) databases, as well as additional supporting literature. 22 per cent is a value reported for Beijing, whereas 175 per cent has been found for Tokyo. The exact current values are not identified.

Sources in the literature

Key sources for this indicator include UITP (2001, 2005); Shah (2012), ITF (2013), LTA Academy (2011). De Gruyter et al (2017) is also proposing to use it. The report 'Cities on the Move' (World Bank 2002) has a wider discussion on urban public transport finance measurements, and the ITF report 'Funding Public Transport' (ITF 2013) brings many case studies.

Data availability, methods to provide data, and examples

All major urban transport public companies (metros etc.) would have the data available on an annual basis in their reports or accounts. Other, minor public transport operators should also be able to provide the data from their annual accounts as it is a critical financial indicator.

An example from an annual report of a regional transport company in a major Asian city is shown in Figure 7.

In this case, the Fare box ratio for 2012 would be $13,168,409/11,077,291 = 119$ per cent

Figure 7. An example of annual report of a transport company

	2012		2011	
	Amount	%	Amount	%
Operating revenues				
Fare revenues	\$ 13,168,409	88	\$ 12,148,726	87
Other operating revenues (Note 18)	1,770,105	12	1,822,467	13
	14,938,514	100	13,971,193	100
Operating costs (Notes 7, 17 and 18)				
Transportation costs	(11,077,291)	(74)	(10,190,443)	(73)
Other operating costs	(858,498)	(6)	(812,541)	(5)
	(11,935,789)	(80)	(11,002,984)	(78)
Gross profit	3,002,725	20	2,968,209	22

Further comments

The fare box ratio is only one of several indicators used to measure public transport financial sustainability. It is not always true that increasing fare box ratio is critical for financial sustainability. Funding of public transport operations can come from various sources, including government subsidies, dedicated taxes, sale or rent of land, or other commercial operations conducted by public transport providers (as in for example Tokyo, see ITF 2013).

In addition, not all cities offer the same opportunities for a high fare box recovery rate, e.g. due to lower population densities. Systems with high capital costs may reduce operating costs (e.g. due to automation) and thereby perform better in terms of the fare box than for example some bus companies, which is why comparison across cities may be challenging. However, increasing the fare box ratio generally relieves the need for other funding sources and indicates that the company is successful in attracting customers willing to pay for the service. This indicator should be considered together with other indicators in the SUTI measuring other aspects of public transport.

4.8 Indicator 8: Investment in public transportation systems

Relevance

Investment in public transport is relevant for several aims and objectives including the 'shift' strategy in the sustainable mobility paradigm.

Relates to SDG target 11.2 "By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all".

Relates to the economic dimension.

Definition

Share of all transport investments made by the city that is directed to public transport.

Unit

per cent of transport investment spending; running five-year average.

It is proposed to average over five years because annual investments tend to fluctuate much over time at local level. A sharp drop when a major scheme is completed will not necessarily imply that the transport system of the city is suddenly more unsustainable. 5-year average is suggested for similar indicator by Dimitriou and Gakenheimer (2011).

Interpretation

Relatively clear-cut; Increasing is positive

Rather than using 'transport investment by mode', which would be difficult to interpret from sustainability point of view, it is proposed to focus on the share of PT in the total investments which is somewhat more straightforward to interpret. However, it cannot necessarily be assumed that massive PT investment in all cases are more sustainable than for example, operational efficiency measures, investments in non-motorized modes, or investment in (road) safety.

Minimum value

10

Maximum value

50

Comment to Minimum-Maximum

The minimum-maximum is informed by based data from the UITP 'Millennium Cities Database' (UITP 2001). In this database values from 12 to 85 per cent occur, but these are annual values that are likely to even out when observed as average over five years. In some years a city may dedicate more than

50 per cent of all its transport investments to public transport but within a five -year average this would more rarely be the case.

Sources in the literature

Mentioned by Bongardt et al (2011); Dobranskyte-Niskota et al (2009); Klang Valley, Malaysia study Bachok et al (2015), UITP (2001), Dimitriou and Gakenheimer (2011).

Data availability, methods to provide data, and examples

Data should be available in cities through public expenditure and project accounts. Not available in global or regional databases generally.

Further comments

A similar indicator, the split of investments by public and private share, is presented with data for cities in Asia and elsewhere in Dimitriou and Gakenheimer (2011). A somewhat similar indicator, transport investment by mode, is proposed by Bongardt et al (2011) and Dobranskyte-Niskota et al (2009) for national-level reporting based on national account data. It is also selected by Bachok et al (2015) in a set of indicators for a regional study in Klang Valley, Malaysia.

There could be issues with data availability, and interpretation of results when comparing across cities

It is an issue for further consideration that investment shares tend to fluctuate over years. A running five-year average should help even this out, but the longer the averaging period, the less visible the changes become. A piloting study could consider different averaging periods.

The availability of subsidies for investments e.g. from central government will obviously affect the level of investments. The most reasonable approach is to subtract subsidies and focus only on the committed investments of the city/regional government and from local sources.

4.9 Indicator 9: Air quality (PM10)

Relevance

More than 80 per cent of people living in urban areas that monitor air pollution are exposed to air quality levels that exceed WHO limits. Traffic is a major source of air pollution in cities causing significant health problems as well as impairing visibility and affecting ecosystems and agriculture.

Relates to the environmental dimension; affecting both 'People' and 'Planet' and indirectly 'Prosperity' due to external costs.

This indicator is to be applied to monitor SDG Target 11.6 By 2030, "reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management".

Habitat (2016) mentions that the indicator is useful for estimating effects of sustainable transport policies.

Definition

Annual mean levels of fine particulate matter (PM10) in the air (population weighted) compared to threshold.

Unit

Micrograms per cubic meter ($\mu\text{g}/\text{m}^3$).

Interpretation

Clear-cut: Decreasing is positive. However not necessarily only attributable to transport.

Minimum value

150 ($\mu\text{g}/\text{m}^3$)

Maximum value

10 ($\mu\text{g}/\text{m}^3$)

Comment to Minimum-Maximum

The minimum-maximum is based on high and low values found for the cities reported by e.g. Reddy and Balachandra (2013). This study includes heavily polluted developing cities in India as well as relatively clean affluent cities such as Singapore.

Sources in the literature

Habitat (2016); WHO (2016)

Data availability, methods to provide data, and examples

WHO has a database of measurements from now over 1.600 cities worldwide, and growing. More cities are covered for PM10 (used here), whereas PM2.5 is more accurate as a health indicator. Figure 8 shows air quality data for various cities in Thailand based on “Bangkok Ambient Annual Summary of Air Quality Data” (www.who.int) (WHO, 2014).

Figure 8. Air quality data for cities in Thailand

Country	City/station	Annual mean, $\mu\text{g}/\text{m}^3$		Year
		PM ₁₀	PM ₁₀	
Thailand	Bangkok	38		2012
Thailand	Chachoengsao	27		2012
Thailand	Chiang Mai	42		2012
Thailand	Chiang Rai	70		2012
Thailand	Chon Buri	21		2012
Thailand	Khon Kaen	36		2012
Thailand	Lampang	57		2012
Thailand	Lamphun	47		2012
Thailand	Loei	38		2012
Thailand	Mae Hong Son	44		2012
Thailand	Nakhon Ratchasima	55		2012
Thailand	Nakhon Sawan	38		2012
Thailand	Nan	44		2012
Thailand	Narathiwat	33		2012
Thailand	Nonthaburi	34		2012
Thailand	Pathum Thani	47		2012
Thailand	Phayao	54		2012
Thailand	Phrae	61		2012
Thailand	Phuket	21		2012
Thailand	Ratchaburi	31		2012

Further comments

Particles do not only reflect pollution from traffic but also from other sources. However, traffic is major contributor. It could be relevant to consider if some adaptation is possible, e.g. using only data from monitors placed in street canyons or the like.

Another proposal is to use number of days exceeding air quality limits rather than absolute average values. The indicator 'Number of days particulate matter PM10 concentrations exceed 50 µg/m³' is for example used in European 'Urban Audit/City Statistics' (Zito and Salvo 2011). These data are not reported in the publicly-available WHO city database (2016).

An alternative providing a more accurate picture of transport contribution would be to calculate all transport emissions to use as an indicator. This will require comprehensive traffic flow data, for example based on a traffic model. A detailed methodology and further guidance to this is provided in WBCSD (2016).

4.10 Indicator 10: Greenhouse gas emissions (CO₂ eq tons/year)

Relevance

Transport contributes worldwide to around one quarter of the global CO₂ emissions. A major proportion is emitted in cities.

Relates to 'Planet', 'People' and 'Prosperity' especially for future generations.

Is relevant for SDG 13 'Take urgent action to combat climate change and its impacts, even if the goal does not directly specify GHG targets for the urban level.

Monitoring CO₂ emissions is essential for all strategies to Avoid, Shift or Improve transport systems from the point of view of climate change.

Definition

CO₂ equivalent emissions from transport by urban residents per annum per capita.

Unit

Ton CO₂ equivalent emitted/capita/year

Interpretation

Clear-cut: Decreasing is positive.

Minimum value

2.75

Maximum value

0

Comment to Minimum-Maximum

The minimum and maximum directly based on WBCSD (2016). No cities report zero emissions, but several cities and regions do aspire to a zero level (see e.g. EST Forum 2013)

Sources in the literature

WBCSD (2016), WRI (2014); IPCC, several others

Data availability, methods to provide data, and examples

Data is typically not immediately available. Emissions from the transport system of a city need to be calculated based on data for transport flows and vehicle types, and/or fuel consumption data.

WRI (2014) makes the distinction between two approaches to estimate a CO₂-emission figure for transport in an urban area,

- Top-down approaches start with fuel consumption as a proxy for transport activity. Here, emissions are the result of total fuel sold multiplied by a GHG emission factor for each fuel.
- Bottom-up approaches begin with detailed transport data. Bottom-up approaches generally rely on a framework which combines data for 'ASIF' - Activity (transport volume), Mode share, Fuel intensity, and Fuel types for the vehicle fleet.

The top-down approach is simpler to apply since it does not require detailed data for travel patterns or vehicle fleet composition. It requires fuel sale statistics by type of fuel. On the other hand, it is difficult to obtain fuel sales data that match the fuel consumed by the city population within the city. The World Bank adopted this approach in an urban transport benchmarking study (Henning et al 2011)

The bottom-up approach typically relies on a transport model that derives its data from regularly-updated household travel surveys that calculate travel distance by mode (the A and F)

A full methodology for calculating emissions bottom-up including accounting for well-to-wheel emissions is described in WBCSD (2016).

Cities that have joined the 'Global Compact of Mayors' or similar national/regional networks may have methodologies and data routines to report the indicator in place already.

Further comments

More limited or indirect indicators may be considered such as monitoring the uptake of zero- or low carbon emission vehicles in the vehicle fleet, in general or for major urban fleets such as buses.

Another option is to use relative performance improvements as indicators rather than absolute value of emissions-per-capita. This could for example be average fuel efficiency of vehicle fleet in the city, or the share of vehicles in various emission/efficiency classes if standards have been defined nationally. Similar data challenges may affect the feasibility of such alternative indicators, which could be explored in pilot study.

5. Sustainable Urban Transport Index

In this chapter, the design of the index is presented and the potential results exemplified. The chapter explains the choices made and alternatives considered regarding normalization, weighting and calculation. The proposed methodology follows to a large degree the one adopted for the UNDP's Human Development Index, but also several indices used in the sustainable transport area.

The method is illustrated with a Microsoft excel spreadsheet using a combination of real and hypothetical data.

5.1 Normalization

Indicators on different scales need to be normalized before comparison and aggregation is possible.

The method applied uses linear rescaling which is a common approach in composite index design (Nardo et al. 2005). It is also often used for designing sustainable transport indices (Zito and Salvo 2010; Zheng 2013; Ahangani et al 2015). This allows for a simple transformation to a linear scale 1-100 for each indicator. The formula used is the following,

$$Z_{i,c} = \frac{(X_{i,c}) - (X_{min,i})}{(X_{max,i}) - (X_{min,i})} * 100$$

Where Z is the normalized indicator X for topic i and city c.

X_{min} is the lowest value of the indicator in actual units, whereas X_{max} is the highest value.

The next question is how to define the goal posts, the minimum and maximum.

In this case minimum and maximum were defined as lowest and highest value found or expected for each indicator based on real performance information in literature, as explained for each indicator in chapter 4. Key sources to identify minimum and maximum values for the selected indicators have been mentioned under each indicator in chapter 4. Key references include WBCSD (2016); Arthur D Little (2014); and Reddy and Balachandra (2013).

Another option is to use a desired target level as the maximum. In this study, this approach was used in a few cases, including for indicator 5 Traffic fatalities and indicator 10 GHG emissions. In both cases the desired level is 0 (0 is therefore used as maximum value to indicate best performance'). Political statements on sustainable transport like 'Bali Declaration' of 2013 explicitly speaks about zero-goals for accidents and pollution (EST Forum 2013).

A third option is to use relative ranking among the pool of observations that is, all cities (the minimum and maximum is set after worst and best city each year). This avoids the need to define the scale in advance. However, this method also makes it impossible to track progress over time for each city compared to other cities. Increase in rank among cities could be the result of other cities performing worse and thus misleading. For the Human Development Index (UNDP 2015) relative ranking was abandoned for this reason and replaced by fixed goal posts.

5.2 Weighting

In constructing a composite index, it is necessary to decide how to weigh each element. Essential elements affecting the desired outcome more than others should have higher weight. Weight can be determined by theoretical considerations, by political or subjective choice, or by expert knowledge on the influence of each factor on the outcome. 'Equal weight' is obviously also a weighting choice.

In their sustainable transport indicator study, Zito and Salvo (2011) argue against weighting. Their reason is that by definition, the three dimensions of sustainability should have equal weight in decision making. This is in accordance with a balanced view of sustainability. The same view is adopted by De Gruyter et al (2017) in their recent study on sustainability measurement of urban public transport in Asian cities.

Alternatives to this position can be argued. One alternative view is the strong sustainability position (Pryn et al. 2015). In this position protecting environmental limits and planetary boundaries should have a higher priority than economic and social concerns in case these limits are threatened, as they arguably are, not least in the case of greenhouse gas emission and climate change.

Others may argue that problems such as climate change should not be the primary concern for urban transport planners in developing cities, considering the urgent need to provide basic access and safe mobility options for large and rapidly growing groups of urbanizing populations.

In case of SUTI following the approach of sustainable development and treating three dimensions equally, equal weight for ten indicators is considered. A formula is used that gives equal weight 0.10 to all ten indicators. A weighting element will be included in the calculation of the index, to test its sensitivity to weighting and in case it should be decided to allow cities using the SUTI to apply a certain weighting, for example based on local priorities, conditions or stakeholder consultations.

However, if the index is to be applied in a comparative way, it is obviously essential that the same weights are used across cities

The weights in the default position are shown along with other aspects of the indicators in Table 14.

Table14. Overview of sustainable urban transport index

Nos.	Indicators	Natural units	Weights	Normalization	
				MIN	MAX
1	Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modes	0 - 16 scale	0.10	0	16
2	Modal share of active and public transport in commuting	Per cent of trips	0.10	10	90
3	Convenient access to public transport service	per cent of the population	0.10	20	100
4	Public transport quality and reliability	per cent satisfied with service	0.10	30	95
5	Traffic fatalities per 100,000 inhabitants	Number of fatalities	0.10	35	0
6	Affordability – travel costs as part of income	per cent of income	0.10	35	3.5
7	Operational costs of the public transport system	Cost recovery ratio	0.10	22	175
8	Investment in public transportation systems	per cent of total investment	0.10	0	50
9	Air quality (PM10)	µg/m ³	0.10	150	10
10	Greenhouse gas emissions from transport	Tons/capita/year	0.10	2.75	0
			1.00		

5.3 Calculation method

There are different possible formulas to use to aggregate results from the indicators.

Two basic options are to use either arithmetic mean or geometric mean.

The arithmetic mean is additive. The components are added together and divided by the number of components; in the case with 10 indicators the formula could be written as in (1).

$$(1) X = \frac{(i_1+i_2...+i_{10})}{10}$$

Where, X is the overall index, composed of the 10 indicators $i_1 - i_{10}$

There have been some critiques of the additive index. First, this assumes linear substitution between the elements. One unit of negative change e.g. traffic accidents can be compensated by one-unit positive change in accessibility. This is not necessarily corrected or acceptable. It is also observed that ranking in additive index is sensitive to a possible change of goal posts.

An attractive feature of the geometric mean is that it rewards consistency of achievements across topics, so a city will score a little higher if it performs relatively similar for all indicators. In this way, a city with a focus on performance for a few measures while completely neglecting others is penalized.

These types of critiques informed the UNDP to change the calculation of Human Development to geometric mean method.

In case of SUTI the geometric the formula can be written like (2),

$$(2) SUTI = \sqrt[10]{i_1 * i_2 * i_3 \dots * i_{10}}$$

Where, SUTI is the overall index, composed of ten indicators $i_1 - i_{10}$.

For some existing indices such as HDI, it has been shown that outcome ranking typically changes little among the two methods in practice (UNDP 2015). However, it can be shown by examples using hypothetical (but realistic) data that the SUTI could lead to some changes in order of ranking among cities depending on which aggregation method is used.

Based on these arguments the geometric mean has been adopted for SUTI.

The introduction of differentiated weights to the SUTI across indicators can be considered at a later stage in the process if desirable.

5.4 Practical calculation

The procedure to calculate results is open for two various levels or approaches. Both procedures can apply an accompanying model excel spreadsheet ('SUTI sheet').

One approach is that individual cities collect data for ten SUTI indicators and enter them in the SUTI excel sheet for an individual city.

There are ten cells to fill in each year (if the reporting is done annually), one for each indicator. When data are entered, normalized values are automatically calculated in a lower table, and a spider diagram is seen. The diagram shows the city's performance within the minimum-maximum scale for all 10 indicators without aggregation to one index.

The other approach is that cities collect data and submit them to a central agency such a UNESCAP who enters data into the SUTI excel sheet for multiple cities.

For each city, there are ten cells to fill in (if the reporting is done annually), one for each indicator. When data are entered, normalized values are automatically calculated in a lower table, and a spider diagram is seen. The diagram shows all the cities' performance within the minimum-maximum scale for all ten indicators, facilitating comparison for each indicator.

In addition, an aggregate index value is calculated for each city using indicator values and weights. This allows to (manually) creating a ranking table of the cities starting with the highest performer on top. This ranking is intended as the main output of the SUTI calculation for multiple cities.

If actual data would be collected for a considerable number of cities (say from 20 to several hundred) it is clearly not practical to include all results in one spider diagram. Here the ranking table would provide a more useful summary result. It would also be possible to make similar spider diagrams or ranking tables for limited selections of cities, e.g. comparing capital cities in a sub region, or comparing a set of cities with similar features.

5.5 Exemplification

Some examples are provided for illustration, using the accompanying SUTI sheet. The examples illustrate both the use of the index for a single city to assess its performance, and for comparing and ranking across a range of cities.

The cities are hypothetical but the performance data are within the range of typically observed, reasonable values for each indicator, and some example data are obtained from actual cities. City 'X' in the individual example is partly molded over the city of Indore, with data as reported in WCBSD (2016b). However, the SUTI and WCBSD indicators only partially overlap, so the illustration does *not* indicate actual full performance of Indore city.

Table 15 shows the indicators with weights (here equal weights are assumed) and minimum-maximum values. The entered data for ten indicators for City X is seen in the right cell.

Table 15. Data entry for individual city

Nos	Indicators	Natural units	Weights	Range		Year A
				MIN	MAX	City X
1	Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modes	0 - 16 scale	0.1	0	16	1
2	Modal share of active and public transport in commuting	Per cent of trips	0.1	10	90	65
3	Convenient access to public transport service	per cent of population	0.1	20	100	53
4	Public transport quality and reliability	per cent satisfied	0.1	30	95	61
5	Traffic fatalities per 100,000 inhabitants	Number of fatalities	0.1	35	0	16.42
6	Affordability – travel costs as part of income	per cent of income	0.1	35	3.5	30
7	Operational costs of the public transport system	Cost recovery ratio	0.1	22	175	87
8	Investment in public transportation systems	per cent of total investment	0.1	0	50	18
9	Air quality (PM10)	µg/m ³	0.1	150	10	100
10	Greenhouse gas emissions from transport	Tons/capita/year	0.1	2.75	0	0.48
	MUST SUM TO 1		1.0			

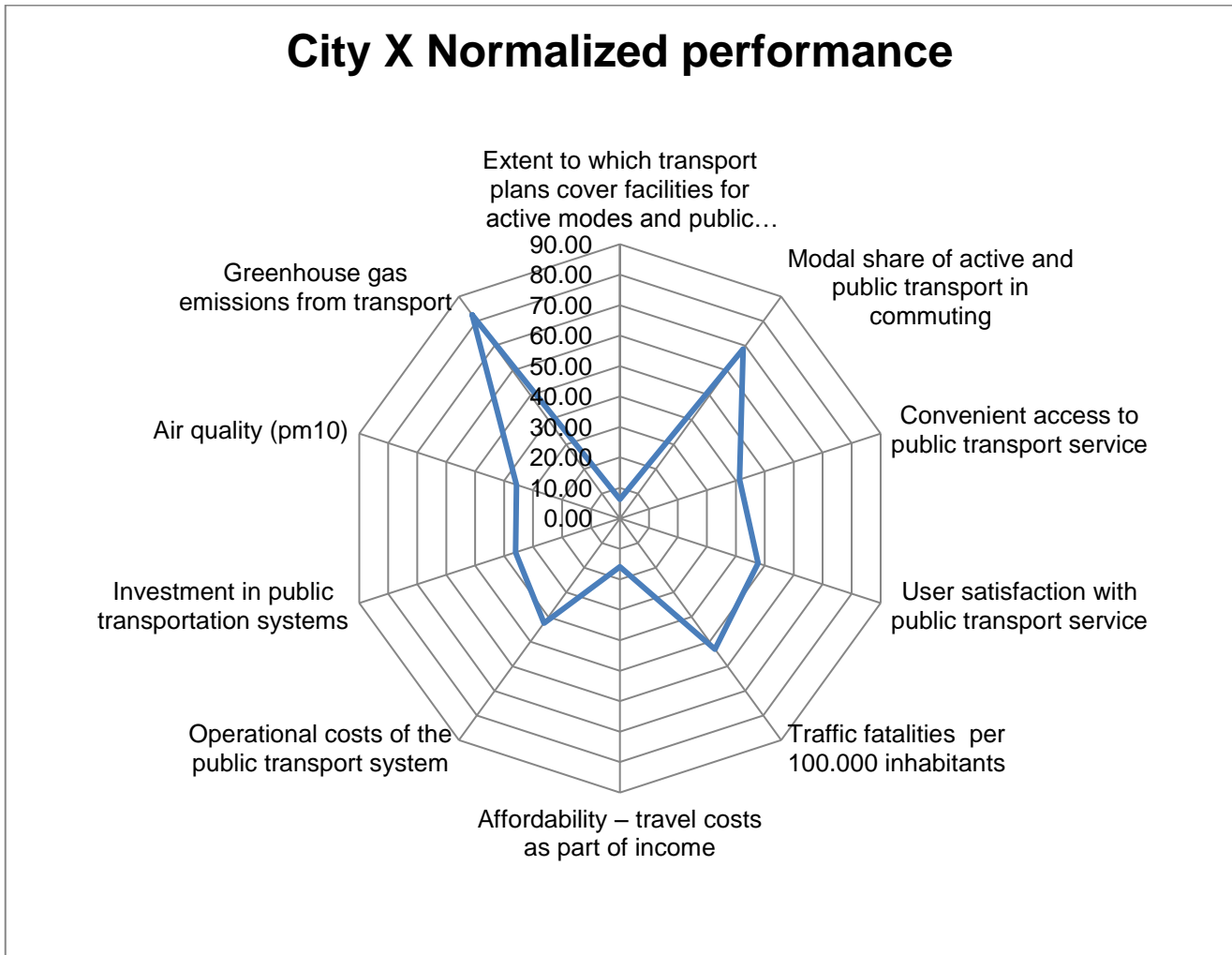
Table 16 shows the calculation of the normalized values.

Table16 Normalized result for individual city

No.	Indicators	Natural units	Weights	Range		Year A
				MIN	MAX	City X
1	Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modes	0 - 16 scale	0.1	0	16	6.25
2	Modal share of active and public transport in commuting	Per cent of trips	0.1	10	90	68.75
3	Convenient access to public transport service	per cent of population	0.1	20	100	41.25
4	Public transport quality and reliability	per cent satisfied	0.1	30	95	47.69
5	Traffic fatalities per 100,000 inhabitants	No of fatalities	0.1	35	0	53.09
6	Affordability – travel costs as part of income	per cent of income	0.1	35	3.5	15.87
7	Operational costs of the public transport system	Cost recovery ratio	0.1	22	175	42.48
8	Investment in public transportation systems	per cent of total investment	0.1	0	50	36.00
9	Air quality (PM10)	µg/m ³	0.1	150	10	35.71
10	Greenhouse gas emissions from transport	Tons/capita/year	0.1	2.75	0	82.54
MUST SUM TO 1			1.0			

Figure 9 shows the resulting spider diagram. Each ‘corner’ represents one of the ten indicators and the rings show levels of performance from minimum (at center) to maximum (outer rim).

Figure 9. Spider diagram showing performance of City X across SUTI indicators



The city can immediately observe areas where it performs well compared with the expected range of low to high performance (in this case for example greenhouse gas emissions from transport), as well as areas to potentially focus on for improvement (in this case for example making sure that future transport plans address active and public transport to a higher degree). This information obtained is without directly comparing with any other city.

The next part illustrates the comparative approach and ranking for a set of eight cities.

As mentioned earlier, the eight cities are partly hypothetical and partly based on real city data. City 1 is the same as City X in the example above. Cities 2 and 3 are partly molded over the cities of Mumbai and Bangalore as reported in Reddy and Balachandra (2013). Cities 4, 5 and 6 are partly molded over London, Singapore and Shanghai as reported in Reddy and Balachandra (2013) as well, supplemented by a data collected from Singapore Land Transport Authority and Transport for London websites.

Table 17 illustrates data entries for the eight cities for each indicator. Normalized values are calculated automatically in the same way as for the individual city indicator.

Table 17. Data entries for eight cities

No.	Indicators	Year A							
		City 1	City 2	City 3	City 4	City 5	City 6	City 7	City 8
1	Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modes	1	3	2	11	11	9	2	8
2	Modal share of active and public transport in commuting	65	73	56	50	57	60	81	52
3	Convenient access to public transport service	53	88	46	83	89	77	44	66
4	Public transport quality and reliability	61	88	59	67	95	81	51	54
5	Traffic fatalities per 100,000 inhabitants	16.42	3.3	9.4	1.6	1.1	11,0	22,0	13,0
6	Affordability – travel costs as part of income	30	28	21	7	9	18	25	18
7	Operational costs of the public transport system	87	67	33	90	136	41	101	79
8	Investment in public transportation systems	18	12	24	45	33	35	15	32
9	Air quality (PM10)	100	132	90	31	25	50	75	74
10	Greenhouse gas emissions from transport	0.48	0.33	0.55	1.1	0.9	0.8	0.4	0.6

In the sheet, the indicator values per city are aggregated to calculate the SUTI, assuming equal weight to each indicator and applying geometric mean for the aggregate value. This produces a dimensionless index.

Table 18 shows the calculated SUTI results for the eight cities. Left column shows the derived index scores and right column ranks the cities according to the score.

Table 18. SUTI ranking for eight cities

Index Scores		Rank by score	
City 1	35.54	City 5	77.90
City 2	42.22	City 4	69.60
City 3	36.33	City 6	56.30
City 4	69.60	City 8	53.48
City 5	77.90	City 2	42.22
City 6	56.30	City 7	39.39
City 7	39.39	City 3	36.33
City 8	53.48	City 1	35.54

It is seen that 'City 5' (vaguely resembling Singapore) is ranking in top, while 'City 1' (vaguely resembling Indore) is ranking third last. It is not surprising if wealthy cities like Singapore generally outperform developing cities on most indicators. However, the point here is not the actual performance of those or other cities but to illustrate the concept.

Rankings of cities could also be produced for the individual indicators (e.g. fatalities or quality and reliability of public transport).

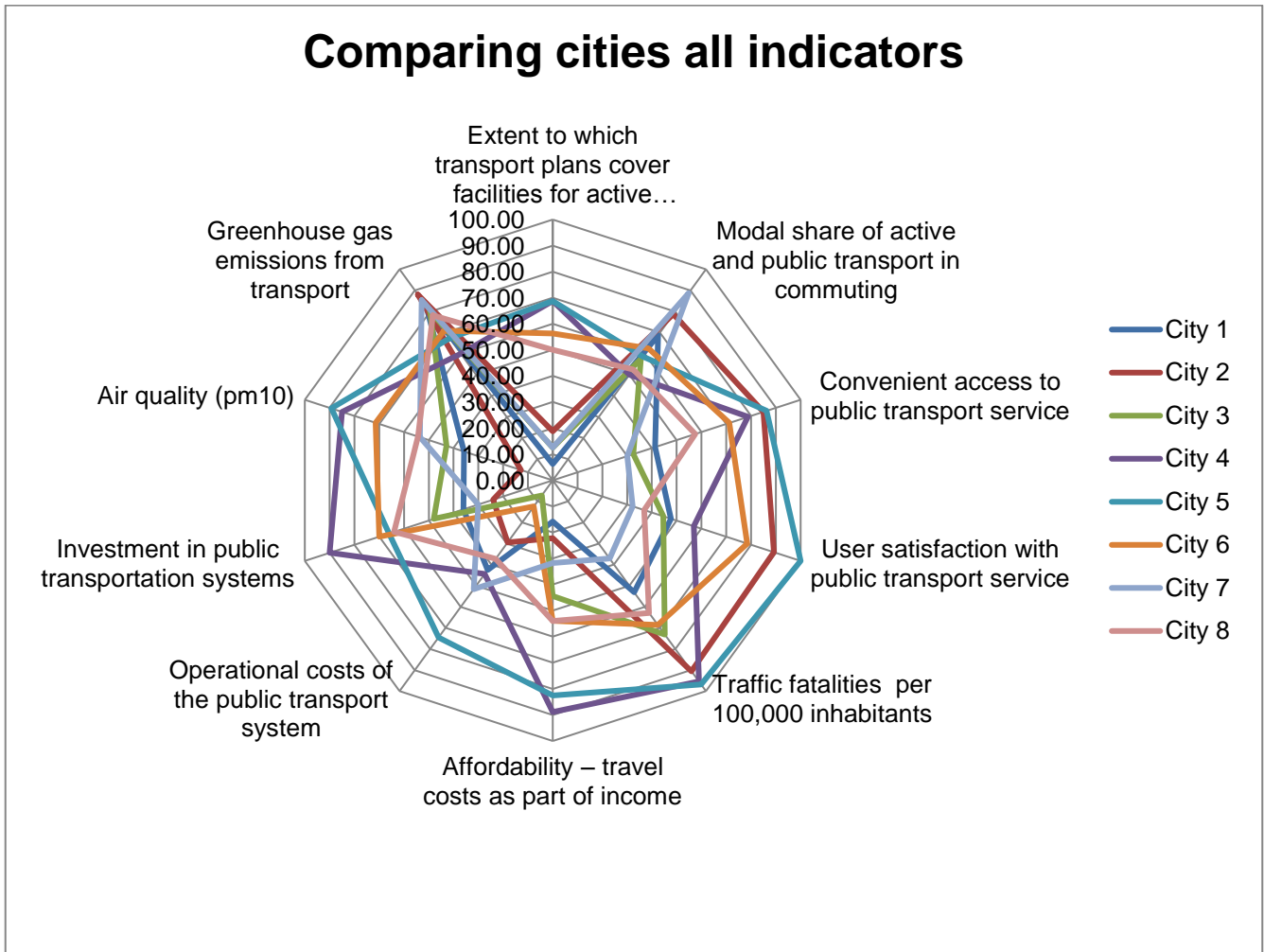
Figure 10 shows a spider diagram of performance for those cities. This is another way to illustrate results at the more disaggregate level without directly aggregating results across indicators.

The colored lines in the charts make it easy to select a city and compare its performance with others. For example, it is observed that 'City 4' (partly molded over London) performs well in most categories. Some cities have similar performance across most indicators, whereas others (like 'City 1') have a very staggered performance with some high, some low scores.

The graphic illustrations will work best with a limited number of cities and indicators. It can be used to supplement, or replace the ranking presented above.

The spider graph does not identify best performer overall, as is seen in the index. In this example indicators carry the same weight. It is possible to apply different weights, if relevant.

Figure 10. Illustration of performance of cities across indicators



6 Summary and Conclusions

6.1 Summary

The sustainable urban transport index with ten indicators describing key aspects of sustainable urban transport for Asian cities was developed for assessment of urban transport systems. The report described the process from developing a conceptual framework, expert consultation and finalizing the indicators set and index for use by cities and countries.

It was possible to define a suitable framework and to identify a wide range of indicators in the literature that are potentially relevant to measure for sustainable urban transport. First 426 (overlapping) indicators were identified in the 25 selected reports and studies. Criteria to review and select indicators based on literature were defined and applied using a subjective assessment approach.

The selection led first to a consolidated mid-range list of 22 indicators. This list was further reviewed for consistency using framework-based criteria and methodological criteria. Some indicators were replaced. The result was a list of eight proposed indicators in four sub-domains to be used in the SUTI.

The panel of experts attending the Expert Group Meeting on Planning and Development of Sustainable Urban Transportation Systems held in Kathmandu on 22-23 September 2016 reviewed the proposed indicators and SUTI and suggested some revisions. Two more indicators relating to public transport and the SDG 11.2 target on sustainable urban transport systems were added, and adjustments were made to some of the other indicators. In addition, the proposed four sub-domains were eliminated on the advice of experts.

For each indicator, concise definitions have been provided along with guidance on ways to collect data and report on them. The selected indicators were used to build an aggregate SUTI, partly inspired by methods used for the Human Development Index. The calculation method is based on normalizing indicators using ranges with minimum and maximum values for cities as goal posts. These are mostly based on data for lowest and highest performance for existing cities.

The indicators are given equal weight in the index, since there is no general basis for differentiating among them. However, it is possible to apply a different weighting scheme.

The calculation method for the index has been described and illustrated and an excel sheet is provided. Index results were illustrated in tables and figures for an individual city and eight hypothetical cities, which for some indicators are based on existing cities and for others represent plausible ranges of values.

The final set of ten indicators and index was agreed at the Regional Meeting on Sustainable Urban Transport Index held in Jakarta on 2-3 March 2017.

6.2 Conclusions and further steps

The most important general issue to consider is the availability of suitable data. The data need not only to be available for relevant cities, but also comparable (based on similar methods) and regularly updated. There are some existing data sources for a few of the proposed indicators but there is no comprehensive and systematic data source available in Asian context. Therefore, additional efforts of city authorities are needed to collect and compile data for ten SUTI indicators.

Pilot application of SUTI is ongoing in selected cities four cities Colombo, Greater Jakarta, Hanoi and Kathmandu). Technical support has been provided to pilot countries and cities to collect urban transport data and analyze SUTI. Guidelines for data collection and extraction for ten indicators has been developed. It would be interesting to see the result and experience of these four cities to further overcome data limitation and application of SUTI in the Asia-pacific region.

It is hoped that the sustainable urban transport index will be a useful tool for cities to assess the achievement of SDG target 11.2 and take policy measure to improve urban transportation systems and services. It is expected that cities and countries would gradually adopt the indicators and index and use them to assess urban transportation systems.

Some existing data sources for a few of the proposed indicators has been identified. Of the proposed indicators only Air quality seems directly available in a common database (WHO) including many cities in the Asia-Pacific region. Traffic fatalities are also widely in use and reported to the WHO at country level. WRI (2016) reports fatality data at city level for a limited number of cities but data would likely have to be collected from a broad range of local/national sources. Even these data are only available for a range of cities and years, not generally for all.

Many international initiatives are currently active or underway to define and collect indicators to monitor various aspects of sustainable transport at the urban level, either as the main focus or as part of wider monitoring efforts. These include efforts by bodies such as UN HABITAT's City Prosperity Initiative (CPI), with more than 400 cities involved; the Sustainable Mobility 2.0 project of the World Business Council on Sustainable Development, with a more focused effort, the Mobility in Cities database and associated indicator reports by the UITP, the activities of bodies like the World Council on City Data, the international Union on Public Transport (UITP), The International Telecommunication Union, the Covenant of Mayors.

The World Bank initiative "Sustainable Mobility 4 all" which is now underway may offer new avenues for reporting on sustainable transport on a global scale. Similarly, the 'Mobility Analytics Partnership' initiated by the ITDP may help progress on urban mobility reporting specifically.

Possibly some of these initiatives could help overcome data availability issues for several of the urban transport indicators included in the SUTI.

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